2-D
PEER REVIEW OF SCIENTIFIC INVESTIGATIONS CONDUCTED FOR PHASES I, II, AND III OF THE MARINE OUTFALL SITING STUDY

FINAL ENVIRONMENTAL IMPACT STATEMENT

Brightwater Regional Wastewater Treatment System

APPENDICES

Final

Appendix 2-D
Peer Review of Scientific Investigations Conducted for Phases I, II, and III of the Marine Outfall Siting Study

August 2003

For more information:
Brightwater Project
201 South Jackson Street, Suite 503
Seattle, WA 98104-3855
206-684-6799 or toll free 1-888-707-8571

Alternative formats available upon request
by calling 206-684-1280 or 711 (TTY)

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

Contents

PEER REVIEW EVALUATION

Of technical documents from the
MARINE OUTFALL SITING STUDY

July 2003

Prepared for:

King County Department of Natural Resources and Parks
Water and Lands Resources Division
201 South Jackson Street, Suite 503
Seattle, WA 98104-3855

Prepared by:

Puget Sound Action Team
Office of the Governor
State of Washington
P.O. Box 40900
Olympia, WA 98504-0900

PUGET SOUND
ACTION TEAM
Office of the Governor

Interagency agreement between the King County Department of Natural Resources, Water and Land Resources Division and the Puget Sound Action Team, Office of the Governor, State of Washington.

Intergovernmental Contract – IAC 200101

To obtain this publication in an alternative format, please contact the Action Team's ADA coordinator at (360) 407-7300. The Action Team's TDD number is (800) 833-6388.

EXECUTIVE SUMMARY

In 1999 the King County Department of Natural Resources and Parks (KCDNRP) initiated a Marine Outfall Siting Study (MOSS) for a new secondary treated wastewater facility named *Brightwater.* Numerous scientific field studies were undertaken in central Puget Sound in areas specific to the candidate outfall zones and pipe corridors. As a result, a large number of technical documents were produced in 2001 and 2002. In 2002 King County identified the need for a formal scientific peer review of 28 technical documents produced during MOSS *Phases I, II and III*. The Puget Sound Action Team was contracted to coordinate this peer review process. Independent and external scientific peer review is an essential component of the scientific process, and lends credibility to such investigations.

The principal scientific disciplines required for this peer review were geology, physical oceanography, biology, modeling, chemistry, and risk assessment. Prospective candidates for a peer review were selected during the fall of 2002 and the six-member panel of marine experts was finalized in December 2002. The technical expertise of the peer review panel was broad-based, and several members served on previous scientific panels concerning marine outfalls.

The objective of the peer review was to make certain the MOSS scientific examinations were adequate to answer specific siting questions regarding location and design of a marine outfall. Specifically, the expert peer review members were asked to "review and comment on the MOSS scientific investigations to ensure that the information/data are sufficient to answer criteria questions, and provide policy-makers and regional decision-makers with an objective evaluation regarding the adequacy of the scientific studies that will be used to inform the final decision on placement and design of a new outfall to Puget Sound" (from the MOSS Peer Review Scope of Work).

This *Peer Review Evaluation* documents the proceedings of the May 1, 2003 meeting and is based on the complete peer review process between October 2002 and May 2003. A set of comprehensive findings and recommendations for each scientific discipline is presented, as well as a project background and details of the peer review process.

PEER REVIEW PROCESS

A kick-off meeting and a final evaluation meeting were scheduled during the peer review process. The kick-off meeting was held on January 9, 2003 at the West Point Treatment Plant in Seattle. The purpose of the meeting was to acquaint the peer reviewers with the MOSS Team (i.e., KCDNRP and other consultant teams), learn about the project, and clarify the reviewer roles and responsibilities. The final evaluation meeting was held at the same location on May 1, 2003 and was a platform for the review panel to present their findings and recommendations, and provide an evaluation of the overall quality of the MOSS scientific studies.

The 28 MOSS technical documents and all supporting materials were distributed to the review panel in early January 2003. The panel members were instructed to review the technical documents and comment specifically on the scientific investigations within each. Several questions were provided to assist the panel during the review of each technical document. For example, reviewers were asked to consider these questions when reading the documents and composing written comments: Were the studies designed appropriately, with sufficient data to satisfy the objectives? Is the science sufficient behind the conclusions? Was sampling sufficient in all cases? Were the correct parameters included? Were the relevant data considered and used appropriately? Was something completely missed?

The reviewers were asked to spend about six to eight days of effort over a six-week period to complete their technical reviews. Each panelist worked independently and provided written, technical comments for every assigned document. The format for a completed review included general comments, detailed comments addressing specific sections in the technical document, a conclusion, and references (if necessary). The length of a review ranged between one and twelve pages depending on the size of the technical document being reviewed.

All reviewers completed the written, technical comments by mid-March 2003 and submitted each review to the peer review coordinator from the Puget Sound Action Team. The review coordinator completed a technical review report (i.e., summary) for each set of written comments. These short summaries encapsulated the reviewer's comments and were written primarily for a technical audience.

The peer review process concluded with the final evaluation meeting on May 1, 2003. Each panelist presented their findings and recommendations for their respective scientific discipline. The material contained in each presentation was a verbal account of the more comprehensive written comments. Panelists were asked to frame their presentations around the five questions listed below. Information derived from these questions serves as the foundation for what is presented in the findings and recommendations.

1. Was the study design scientifically sound (met data quality objectives (DQO) or study purpose)? For example, were parameters clearly defined, goals clearly stated?
2. Were study methodologies acceptable and appropriate? For example, were standard scientific methods and variables used?
3. Were data sufficient to meet the DQO's or study purpose? For example, were enough data, or the appropriate data, collected to meet the study purpose?
4. Did the report adequately present study results? For example, did the reports present sufficient data analysis? Was anything missed? What more is needed?
5. Were appropriate resources/information reviewed and/or presented? This question is specific to literature reviews, and is applicable only to the oceanography and biology disciplines.

PANEL FINDINGS AND RECOMMENDATIONS

Overall conclusions

The six-member independent scientific peer review panel concluded that all 28 technical documents were acceptable. The panel judged that the MOSS scientific studies were adequate to address the siting and design questions concerning the proposed outfall. Extensive and appropriate scientific data were collected for the scientific investigations reported in each technical document. Study designs were scientifically sound and the methods were generally appropriate.

The review panel identified no serious flaws in the MOSS studies that would jeopardize the studies' ability to inform outfall siting and design decisions. However, the panel did recommend improvements that could be made in some areas, including some extensive improvements in a few areas. The recommended modifications could be accomplished by preparing errata sheets, revising existing reports, or writing additional reports. Examples of specific recommendations are offered below under each scientific discipline heading.

The peer review panel commented extensively on the scientific investigations in each technical document and offered numerous recommendations in the written reviews. The panel offered over-arching recommendations that they thought would strengthen the existing technical documents and also provided general guidance based on the panel's technical experience with outfall processes. These include:

- Provide a context for the outfall within Puget Sound: For example,
    a) *Outfall design and general observations*: put proposed outfall into context with existing outfalls in Puget Sound, as well as other outfalls in the United States, and overseas. How would it compare?
    b) *Water quality*: put proposed outfall discharge in context with other loads entering Puget Sound (i.e., stormwater discharges, atmospheric and riverine inputs); seek information from the Total Maximum Daily Load (TMDL) process.
    c) *Risk assessment*: compare numbers with other outfalls;
    d) *Monitoring*: relate water quality and chemistry data to monitoring programs such as the Puget Sound Ambient Monitoring Plan (PSAMP) – seek a better conceptual framework; and
    e) *Other data*: fit components of the biological studies into the larger Puget Sound picture. Also, put sediment data into context with the seafloor bathymetry, where sediments accumulate, and at what rates.
- Report that standards could be met with lesser levels of wastewater treatment, but that the proposed facility will exceed requirements by using secondary treatment with chlorination, and ultimately membrane filtering, an even greater level of treatment. Highlight long-term environmental goals of the proposed facility.
- Develop a summary report emphasizing the overall picture. Incorporate conclusions from the 28 technical documents and produce a 40 - 50 page report

for the public. The report should be readable, understandable, and between a technical document and a public document in scope.
- Develop and submit manuscripts for publication in the peer-reviewed literature. For future work, consider producing reports targeted for peer-reviewed publication in addition to, or in lieu of, agency data reports.
- Conduct further or improved analyses in several areas (e.g., biology, modeling, risk assessment) to address data gaps and strengthen existing data.
- Undertake additional studies such as forage fish spawning surveys and ichthyoplankton surveys; obtain continuous stratification measurements; develop methods consistent with the University of Washington's (UW) oceanographic methods; and utilize better Method Detection Limits (MDLs) - particularly for organic contaminants.
- Improve data interpretation and reporting. As stated previously, all reports were acceptable. However, the panel did suggest that reports should state clearly the intended accomplishments in each study and the rationale. The panelists offered recommendations for improving data interpretation and reporting in the technical reports.

Geology

Two primary technical documents (and one appendix) were reviewed for the geology portion of the MOSS. Physical features of the sea floor and subsurface geology, and identification of potential pipe corridors, diffuser zones, and possible hazards were among the scientific investigations studied and reported in the two primary technical documents.

The geophysical and geotechnical study designs were scientifically sound and the methods were acceptable and appropriate. As a result, an excellent data set was collected. The science followed closely the Detailed Evaluation Questions (DEQ's) listed by the KCDNR. The geotechnical study contained a very good treatise of seismicity in Puget Sound.

The reviewer offered specific recommendations and observations, and suggested ways to improve the existing technical documents. Some of the suggestions for improvements included:

- Both technical documents did not fully reflect the amount and quality of data collected. The reviewer felt that the appendices should contain more detailed information about QA/QC procedures as well as raw data sheets. This could be addressed relatively easily by adding this information to the existing reports,
- Place the outfall design criteria into context with other Puget Sound outfalls – how would it compare?
- Include the initial survey design specifications,
- Describe more completely the methods and instrumentation,
- The science supported the conclusions, but the conclusions could be documented more completely (i.e., add more detailed graphical support), and

- In general, better documentation and improved data presentation are needed.

Physical Oceanography

Three technical documents were reviewed for the physical oceanography portion of the MOSS. Transport processes, water circulation, and mixing in the Triple Junction region of the Puget Sound were among the scientific investigations studied and reported in the three technical documents.

The physical oceanography study design was scientifically sound and well thought out, and the methods were acceptable and appropriate (i.e., "state-of-the-art"). The data collected were the most extensive and detailed for any region of Puget Sound to date. The data analyses were thorough and the results were adequately presented in the reports. The review of existing physical oceanography in Puget Sound was excellent, a comprehensive report covering all relevant documents.

The reviewer offered specific recommendations and observations, and suggested ways to improve the existing technical documents. Some of the suggestions for improvements included:

- Modify the Executive Summary in the final oceanography report to include the potential impacts from an outfall to Whidbey Basin (i.e., low dissolved oxygen in Whidbey Basin), and extrapolate the climate issues during the study period (i.e., dry study year and reduced freshwater river input), and
- Improve the flow schematic diagrams (i.e., color schemes, arrows). These figures are essential for communicating information to non-oceanographers and lay audiences.

Biology

Six technical documents were reviewed for the biology portion of the MOSS. A geoduck survey, marine habitat documentation and distribution of many species, identification of data gaps, forage fish spawning habitat, salmonid and other marine finfish distribution and abundance, and mapping of benthic habitats and vegetation were among the scientific investigations studied and reported in the six technical documents.

The numerous study designs were scientifically sound and the methods were standard and variables appropriate. Goals were clearly stated although the rationale for the study design was sometimes unclear. The data collected were sufficient for most of the biological studies, and future studies are planned to address the data gaps (i.e., focused eelgrass survey and intertidal biota survey). The literature review for spot prawn data was comprehensive. The beach seine study objectives were excellent, and the completed results are forthcoming. The *King County Nearshore Habitat Mapping Data Report: Picnic Point to Shilshole Marina* was an excellent study overall – a keystone report upon which others should be modeled.

The reviewer offered specific recommendations and observations, and suggested ways to improve the existing technical documents, as well as suggesting additional studies. Some of the suggestions for improvements included:

- Relate the results of the biological studies to the proposed outfall siting area and to the overall health of Puget Sound,
- In general, additional and improved graphics are needed, as well as more statistics, more data analyses, and improved data presentation (clarity) and reporting,
- Explain more thoroughly some of the experimental designs (in terms of statistics),
- Potential statistical errors exhibited in one report. If yes, then correct and report results in an errata sheet,
- Insufficient food web discussions in another report. Utilize results from beach seine study to improve these discussions,
- Collect additional biomass data for geoduck (i.e., sample more plots),
- Address data gaps for spot prawns and ichthyoplankton and zooplankton by sampling the same area with two different net mesh sizes,
- The *Submerged Aquatic Vegetation Patterns in Candidate Outfall Zones* report may need to be re-written if the writing style interferes with data interpretation, and
- These issues can be addressed by issuing errata sheets, revising existing documents, or writing additional reports.

Hydrodynamic Modeling

Three technical documents were reviewed for the modeling portion of the MOSS. Mixing zone dilution simulations for each diffuser zone, effluent transport and dilution within Puget Sound (and far field), and predicted effluent dilution at shoreline areas were among the scientific investigations studied and reported in the three technical documents.

The study designs were scientifically sound and the study methodologies were acceptable and appropriate. The data were extensive and sufficient to meet the study purpose in most cases. Oceanographic investigations were excellent, comprehensive.

The reviewer offered specific recommendations and observations, and suggested ways to improve the existing technical documents, as well as suggesting additional studies. Some of the suggestions for improvements included:

- Clearly define the mixing zone terminologies,
- Increase the number of density profiles and currents used in initial dilution simulations. Density profile (stratification) data were insufficient for near field modeling, and raw data for profiles and current speeds was not sufficiently reported,
- Reports could be revised to more fully present study results such as the statistical distribution of rise height and dilution, reproduction of mean currents and

stratification by the Princeton Ocean Model, and intermediate modeling on hourly time scales,
- Continuous measurements of density stratification, improved modeling and analysis of near field behavior, and better assessment of onshore transports would improve these studies,
- The reports would be improved by better discussion of the behavior of wastewater in understandable terms (i.e., basic concepts of outfall behavior) and the trade-offs with outfall design (i.e., diffuser versus open pipe and treatment level), and
- These issues can be addressed by issuing errata sheets, revising existing documents, or writing additional reports.

Chemistry

Nine technical documents were reviewed for the chemistry portion of the MOSS. Water quality, primary productivity and nutrient dynamics, geoduck tissue study, and a baseline characterization of sediment quality were among the scientific investigations studied and reported in the nine technical documents.

The numerous study designs were scientifically sound and complex. Detailed, long-term data sets exist: 30-year water quality sets in some cases. The study methodologies were acceptable and appropriate for most studies and the study results were adequately presented in the technical documents. The water quality status reports are good data reports, as well as good evaluation of compliance. The amount and quality of data collected ranks the ambient monitoring program as one of the best in the country. The data collected for the primary productivity component was especially important since historical data are limited in this region of Puget Sound. These data should be published in the peer-reviewed literature.

The reviewer offered specific recommendations and observations, and suggested ways to improve the existing technical documents, as well as suggesting additional studies. Some of the suggestions for improvements included:

- Relate the chemistry data to existing monitoring programs such as the Puget Sound Ambient Monitoring Program (PSAMP),
- Strive for multi-year trends,
- Seek better detection limits in the effluent,
- Consider new contaminants of concern (i.e., lipophilic pesticides, PCBs, dioxins, estrogen mimics),
- Synthesize further the water quality data presented in the 1999-2000 and 2001 Status Reports,
- Formulate a Puget Sound conceptual framework,
- Consider more sensitive detection limits in the geoduck tissue study (i.e., for PCBs).
- The Washington state sediment standards may be inappropriate (i.e., depth of sediment sampled), and the method detection limits for organics used in the

sediment studies were insensitive. Consider modifying the method detection limits.

- Put sediment data into context with the Sound-wide distribution of sediments. Characterize the outfall's organic contaminant load contributions to the total sediment reservoir currently present in Puget Sound. Provide some comparison so people can better understand what is happening. This is especially important because of the concern for contamination (e.g., PCBs and dioxins) of marine animals and fish.
- These issues can be addressed by issuing errata sheets, revising existing documents, or writing additional reports.

Risk Assessment

Four technical documents were reviewed for the risk assessment portion of the MOSS. Human use surveys along shorelines, and water quality investigations (e.g., achieving water quality standards at edge of mixing zones, risk-based approach to predict potential impacts, effluent concentrations safe for aquatic organisms and humans, environmental impacts, water column and sediment concentrations) were among the scientific investigations studied and reported in the four technical documents.

The study designs were scientifically sound and the study methodologies were acceptable and appropriate. The data were extensive and sufficient to meet the study purposes and the reports adequately presented the study results. The Human Use surveys were comprehensive and well done. The seafood consumption information as related to risk assessment was helpful.

The reviewer offered specific recommendations and observations, and suggested ways to improve the existing technical documents, as well as suggesting additional studies. Some of the suggestions for improvements included:

- Although the study designs were scientific sound, the EPA-based risk assessment failed to guide the reader toward the pertinent and important issues associated with other marine outfalls around the country (i.e., focused attention on chemicals not normally associated with marine outfalls, as well as unlikely exposure pathways [swimming ingestion]).
- Better detection limits for organics are needed; consider a Monte-Carlo approach to capture a range versus the worse case assumptions.
- The risk assessment approach did not allow evaluation of outfalls in the context of indicators currently used in Puget Sound (e.g., those indicators reported in the *2002 Puget Sound Update*). Put the data into context with existing outfalls in Puget Sound, as well as other outfalls and other loads (e.g., PCBs, dioxins) in the country, and the globe. How are other outfalls behaving? What are the numbers and how does this outfall compare?
- Put the wastewater discharge into context with all other loads entering Puget Sound (seek information from the TMDL process).

- Revisit the use of conservative assumptions and cancer risks, consider more fully the issue of estrogen mimics, utilize whole effluent toxicity testing, and report the density and distribution of the fecal coliform data.
- These issues can be addressed by issuing errata sheets, revising existing documents, or writing additional reports.

NEXT STEPS

Input from the review panel regarding data presentation and document content will be incorporated into forthcoming documents produced as part of future studies. Additional scientific studies that are either ongoing, or proposed, include:

- A focused eelgrass survey along the proposed alignment route,
- Completing data analysis and the report for the nearshore beach seining surveys,
- Conducting an intertidal biota survey along the preferred alignment route,
- Additional geotechnical work along the preferred alignment,
- Polychlorinated biphenyl (PCB) mass balance and bioaccumulation modeling; low level PCB sampling in the water column,
- Ambient monitoring for endocrine disruptors and participation in national surveys for effluent,
- Additional sediment chemistry sampling along the proposed alignment routes,
- Continuous water column stratification measurements in the vicinity of the diffuser for the preferred alignment, and
- Additional plume and transport modeling.

In addition, recommendations regarding specific items for the 28 documents reviewed as part of this evaluation will be implemented by KCDNRP. The response to the findings and recommendations provided by the review panel are addressed by KCDNRP in a separate memorandum.

TABLE OF CONTENTS

1.0 INTRODUCTION

This report summarizes the outcome of a four-month external scientific peer review of the King County Department of Natural Resources and Parks' (KCDNRP) Marine Outfall Siting Study (MOSS) - *Phases I, II, and III*. Specifically, this report communicates the proceedings of the final peer review meeting held on May 1, 2003. The Puget Sound Action Team (PSAT) was asked to coordinate a formal peer review of 28 scientific technical documents relating specifically to the marine outfall portion of the *Brightwater* Wastewater Treatment Plant project.

An expert panel of six marine scientists was assembled in December 2002 to conduct a formal peer review of scientific investigations concerning the MOSS project in Central Puget Sound. The objective was to make certain the scientific examinations were adequate to answer specific siting questions regarding location and design of a marine outfall. Specifically, the expert peer review members were asked to "review and comment on the MOSS scientific investigations to ensure that the information/data are sufficient to answer criteria questions, and provide policy-makers and regional decision-makers with an objective evaluation regarding the adequacy of the scientific studies that will be used to inform the final decision on placement and design of a new outfall to Puget Sound" (from the MOSS Peer Review Scope of Work).

This *Peer Review Evaluation* document presents project background information, a description of the peer review process including a list of the panel members and the review timeline, a description of the May 1 meeting, and a summary and comprehensive discussion of the findings and recommendations.

In addition, this report contains three appendices. Appendix A lists the curriculum vitaes for the peer review panelists. Appendix B presents the written, technical reviews with questions and answers (provided by the MOSS Team), and summaries of the written comments completed by the peer review coordinator. Appendix C contains the attendee list for the May 1 meeting.

2.0 BACKGROUND

2.1 Brightwater Project History

The Project Manager for the outfall component of the *Brightwater* Treatment Plant project provided the following description of the three project phases:

> In November 1999, King County adopted the *Regional Wastewater Services Plan* (RWSP). The RWSP serves as the long-term response to the Growth Management Act for wastewater services. One of the main projects specified in the RWSP is the construction of a new regional wastewater treatment system in north King County or south Snohomish County by 2010. King County adopted the name *Brightwater* for the new proposed regional wastewater system.

Also in November 1999, King County embarked on a siting decision process involving three phases of analysis for the new regional wastewater system. *Phase 1* focused on a broad two-county search for potentially suitable treatment plant sites and outfall zones. Potential marine outfall zones along the King County and Snohomish County shorelines were evaluated in *Phase 1* for suitability and eight potential outfall zones were advanced to *Phase 2*. The eight marine outfall zones were identified primarily based on geological characteristics and the ease of constructing an outfall. Additional scientific and community concerns were also addressed using a series of detailed evaluation questions (DEQs).

In *Phase 2*, six candidate *Brightwater* systems were developed, each including a treatment plant, conveyance concepts, and marine outfall zones. Potential marine outfall zones were evaluated and compared to identify the most suitable zones for advancement. Based on the screening evaluation, King County advanced two systems, Edmonds-Unocal (referred to as Unocal) and Route 9, for further evaluation in *Phase 3*. The County also identified four outfall zones suitable for further study: Zones 5, 6, 7N and 7S. Each outfall zone contained one potential diffuser site, except zone 7S that contained two potential diffuser sites (A and B). These four outfall zones were identified using an updated series of DEQs, with consideration given for proximity to the potential treatment plant sites and conveyance alignments.

In the preliminary *Phase 3* screening, 11 conveyance corridors and three outfall zones (zones 6, 7N, and 7S diffuser site B) were identified in the draft environmental impact statement (DEIS) scoping period. Outfall zones 5 and 7S diffuser site A were eliminated from further evaluation based on application of the third phase of DEQs. In the second step of the *Phase 3* evaluation, the conveyance corridors and outfall zones were re-examined to further narrow those alternatives to the best alternatives for detailed evaluation in the project DEIS. Three system packages (treatment plant sites, conveyance corridors, and outfall zones) were identified for detailed review. Two system packages include outfall zone 7S diffuser site B, while the third system package includes outfall zone 6 (Unocal).

In August 2002, the King County executive identified the Route 9 treatment plant site and an outfall in zone 7S diffuser site B, as the preferred Brightwater system alternative. The DEIS was released for public comments on November 6, 2002, with a 75-day comment period. The final EIS is scheduled for release in late 2003.

3.0 PEER REVIEW PROCESS

The process to identify and recruit marine experts to serve as scientific peer reviewers began in late October 2002. Technical experts were required specifically for geology (geophysical and geotechnical), physical oceanography, marine resource biology (including fisheries and invertebrates), hydrodynamic modeling, chemistry and water quality, and human health and aquatic risk assessment. The peer review process is outlined in this section, and described in more detail in sections 3.1 through 3.4.

A search of the Internet and the literature produced a list of candidate scientists from east and west coast universities and federal and state agencies. In addition, prospective reviewers were identified through e-mail and telephone responses after circulating a recruiting announcement at the fall meeting of the National Estuary Program and the Association of National Estuary Programs. A general description of the peer review project and a question gauging interest was emailed to each candidate reviewer (i.e., are you interested and do you have the time necessary to complete this project?).

The six-member peer review panel was finalized in mid-December 2002. A document was distributed to the panel describing project details, anticipated timeline, expectations and products, a list of the 28 technical documents and proposed reviewer (s), and the estimated review time per discipline (e.g., 40-60 total hours for physical oceanography). Each panelist was asked to review this information, revise technical review responsibilities (i.e., appropriate match with assigned reviewer, and accurate estimate of review hours), and provide an estimate of cost to complete all deliverables by May 2003. As a result of this feedback, nearly one-half of the MOSS technical documents in Table 1 were assigned to two or more reviewers (i.e., cross reviewed).

A kick-off meeting and a final evaluation meeting were scheduled during the peer review process. The kick-off meeting was held on January 9, 2003 at the West Point Treatment Plant in Seattle. The purpose of the meeting was to acquaint the peer reviewers with the MOSS Team (i.e., KCDNRP and other consultant teams), learn about the project, and clarify the reviewer roles and responsibilities. The final evaluation meeting was held at the same location on May 1, 2003 and is described in more detail in Section 3.4.

The MOSS technical documents and all supporting materials were distributed to the review panel in early January 2003. Five of the six reviewers completed all written, technical comments by the end of February 2003. The sixth reviewer completed all reviews by mid-March 2003. All full text written comments were submitted to the peer review coordinator, summarized by the coordinator, and returned to the review panel during March and April 2003 for evaluation to ensure accurate interpretation and reporting.

Finally, the panel members were asked to review this document, the *Peer Review Evaluation*, and provide comments and edits to ensure accurate and complete representation of the proceedings of the May 1 meeting.

3.1 Panel Members

The peer review coordinator of the PSAT coordinated the panel member selection process and solicited marine experts from regional and national universities, federal and state agencies, and a Canadian university and federal government ministry. The goal was to identify and recruit five to seven independent marine scientists with technical expertise in the specified disciplines listed in Table 1 (core subjects). Regional representation on the panel was requested by the KCDNRP, specifically for the fishery and macro-invertebrate segment of the biology discipline. Scientists affiliated with any of the MOSS studies were not considered as candidate peer review panelists.

Initially, 44 scientists were contacted in Washington, Oregon, California, Rhode Island, Massachusetts, Georgia, Maryland, and British Columbia, Canada. In addition, a recruiting announcement was circulated at a National Estuary Program conference in the fall of 2002. Of the 44 individuals, 15 responded as interested, and when asked to further consider the roles and responsibilities associated with a peer review process, 11 candidates emerged as committed to project completion. Finally, the field was narrowed to the six panelists after internal discussions between PSAT staff. Relevant expertise, areas of specialization, and budgetary matters were considered.

A list of the recommended peer reviewers was submitted to the KCDNRP prior to notifying the selected candidates. All panelists were financially compensated for their time. Refer to Appendix A for curriculum vitas of each panel member.

<u>MOSS Peer Review Panel Members</u>

Michael S. Connor, Ph.D., Executive Director
San Francisco Estuary Institute
Relevant expertise: risk assessment, ecology, and sediment chemistry

Aimee A. Keller, Ph.D., Marine Research Biologist
Puget Sound researcher (University of Rhode Island)
Relevant expertise: marine resources, biology, fisheries, and primary productivity

Douglas R. Levin, Ph.D., Director
Earth Mapping Laboratory, University of Maryland-Eastern Shore
Relevant expertise: marine geology (geophysics, geotechnical)

Parker MacCready, Ph.D., Associate Professor
University of Washington
Relevant expertise: physical oceanography

Michael J. Mickelson, Ph.D., Program Manager, Outfall Monitoring
Massachusetts Water Resources Authority
Relevant expertise: chemistry (water, tissue, productivity)

Philip J.W. Roberts, Ph.D., PE, Professor
School of Civil and Environmental Engineering, Georgia Institute of Technology
Relevant expertise: hydrodynamic modeling

MOSS Peer Review Coordinator

Daniel K. Averill
Puget Sound Action Team

3.2 Timeline

1. Initiate search for MOSS Peer Review panel members (late October 2002)

2. Finalize and appoint Peer Review panel members (mid December 2002)

3. Assign 28 technical documents to appropriate panelists (early January 2003)

4. Kick-off meeting in Seattle (early January 2003)

5. Panelists review technical documents from early January – late February 2003 and submit written comments (late February – mid March 2003)

6. Panelists review technical review reports (summaries) (March – April 2003)

7. Final Project Evaluation meeting in Seattle (early May 2003)

3.3 Technical Reviews

The 28 technical documents listed in Table 1 were distributed, in hard copy and CD form, to appropriate members of the review panel on January 3, 2003. Supporting materials such as a list of technical sections to review, deliverable titles, products and deadlines, and a kick-off meeting agenda were included. As mentioned in the Introduction, the panel members were instructed to review the technical documents and comment specifically on the scientific investigations within each. Several questions were provided to assist the panel during the review of each technical document. For example, consider these questions when reading the documents and composing written comments: Were the studies designed appropriately, with sufficient data to satisfy the objectives? Is the science sufficient behind the conclusions? Was sampling sufficient in all cases? Were the correct parameters included? Were the relevant data considered and used appropriately? Was something completely missed?

The reviewers were asked to spend about six to eight days of effort over a six-week period to complete their technical reviews. Each panelist worked independently and provided written, technical comments for every assigned document. The format for a completed review included general comments, detailed comments addressing specific sections in the technical document, a conclusion, and references (if necessary). The length of a review ranged between one and twelve pages depending on the size of the technical document being reviewed. The panel reviewed 28 documents but the number of technical reviews (i.e., sets of written comments) totaled 46 as a result of the numerous cross reviews. All technical reviews were transmitted electronically to the review coordinator. Refer to Appendix B for the panel's technical reviews and the review coordinator's summaries of each technical review.

Panel member devoted substantial effort to the review of MOSS documents. Several reviewers provided graphical depictions of data as a means of illustrating data not represented, incorrectly represented, or suggesting ways to improve the interpretation and reporting of existing data. In addition, two panelists requested the outfall-related comments from the *Brightwater* draft EIS. One reviewer provided examples of modeling studies that may be applicable to the Puget Sound region.

The review coordinator completed a technical review report (i.e., summary) for each set of written comments. These short summaries encapsulated the reviewer's comments and were written primarily for a technical audience. After completion, the 46 summaries were returned to the panel for review to ensure accurate interpretation. Finally, the technical review reports and the full text written technical comments were forwarded to the KCDNRP during March and April 2003.

3.4 May 1, 2003 Meeting

The May 1 meeting was a platform for the review panel to present their findings and recommendations, and provide an evaluation of the overall quality of the MOSS scientific studies. The review panel focused on six core subject areas, one area per panelist, encompassing the 28 technical documents: geology, physical oceanography, biology, modeling, chemistry and water quality, and risk assessment. The material contained in each presentation was a verbal account of the more comprehensive written comments included in Appendix B. The format of the meeting did not allow for extensive discussion of every issue, so the reader should refer to the peer reviewer's written comments for this information. Refer to Appendix C for a list of the meeting attendees.

Panelists were asked to frame their presentations around five questions:

1. Was the study design scientifically sound (met data quality objectives (DQO) or study purpose)? For example, were parameters clearly defined, goals clearly stated?
2. Were study methodologies acceptable and appropriate? For example, were standard scientific methods and variables used?
3. Were data sufficient to meet the DQO's or study purpose? For example, were enough data, or the appropriate data, collected to meet the study purpose?
4. Did the report adequately present study results? For example, did the reports present sufficient data analysis? Was anything missed? What more is needed?

5. Were appropriate resources/information reviewed and/or presented? This question is specific to literature reviews, and is applicable only to the oceanography and biology core areas.

A matrix chart was created for each of the six core subject areas and the appropriate MOSS technical documents. The five questions listed above comprised the column headers and the technical documents were listed as rows. Blank matrix charts were distributed to the panelists prior to the meeting and were meant to act as a guide when preparing individual presentations. Each panelist was encouraged to fill in the empty boxes in advance.

The appropriate matrix was displayed as a large wall chart during each presentation. The purpose of this exercise was to illustrate if each MOSS technical document satisfied, or could answer these five questions. The review coordinator recorded a yes or no, plus comments, in each of the empty boxes within the matrix. All matrix charts were filled in by the conclusion of the meeting. Information contained in each matrix serves as the foundation for what is presented in Section 4.0 below.

Dr. Michael Connor was designated as the lead panelist and summarized each panel member's presentation at the conclusion of the meeting. This exercise proved especially valuable, the results of which greatly assisted the production of this report.

3.5 Documents Reviewed

Twenty-eight MOSS technical documents were considered for this scientific peer review. All documents were produced in 2001 and 2002. Table 1 lists the 28 technical documents and the expert reviewer (s) responsible for providing written, technical comments.

Table 1. MOSS technical documents and assigned peer reviewers

Core Subject	Document Title	Peer Reviewer
Geology	Marine Geophysical Investigation: Marine Outfall Siting Study. March 2001	D. Levin
	Brightwater Marine Outfall Conveyance System Interim Conceptual Geotechnical Assessment. May 2002	D. Levin
	Submarine Cultural Resources. September 2001	D. Levin
Physical Oceanography	Review: Puget Sound Physical Oceanography Related to the Triple Junction Region. January 2001	P. MacCready
	Interim Report: Puget Sound Physical Oceanography Related to the Triple Junction Region, Phase 2. September 2001	P. MacCready
	Final Report: Puget Sound Physical Oceanography. November 2002	P. MacCready
Biology	Brightwater Marine Outfall: A Geoduck (*Panopea abrupta*) Survey for the King County MOSS. November 2002	A. Keller
	King County Marine Habitat Report Prepared in support of the Wastewater Treatment Division, Habitat Conservation Plan, and the Brightwater Marine Outfall Siting Study. January 2001	A. Keller
	Biological Resources Report, Phase 2. September 2001	A. Keller

Core Subject	Document Title	Peer Reviewer
Biology (continued)	Brightwater Marine Outfall Phase 3 Biological Resources Report. November 2002	A. Keller, M. Connor
	King County Nearshore Habitat Mapping Data Report: Picnic Point to Shilshole Marina. March 2001	A. Keller, D. Levin
	Submerged Aquatic Vegetation Patterns in Candidate Outfall Zones. September 2001	A. Keller, D. Levin
Hydrodynamic Modeling	Initial Dilution Assessment of Potential Diffuser Zones, MOSS Plume modeling: Continuous discharges to Puget Sound, Phase 2. September 2001	P. Roberts
	Brightwater Marine Outfall: Phase 3 Initial Dilution Assessment of Potential Diffuser Zones. November 2002	P. Roberts
	Brightwater Marine Outfall: Puget Sound Marine Modeling Report. November 2002	P. Roberts
Chemistry	Water Quality Status Report for Marine Waters, 1999 and 2000. September 2001*****	P. MacCready, M. Connor, M. Mickelson, A. Keller
	Water Quality Status Report for Marine Waters, 2001. November 2002 *****	P. MacCready, M. Connor, M. Mickelson, A. Keller
	Geoduck Tissue Study, Brightwater Candidate Marine Outfall Zones, Sampling and Analysis Plans. April 2002	M. Mickelson, M. Connor
	Brightwater Marine Outfall: Geoduck Tissue Study Final Report. November 2002	M. Mickelson, M. Connor
	Existing Water Quality Conditions Study, Offshore Water Column and Intertidal Environments of the Central Puget Sound Basin, Sampling and Analysis Plan. June 2001	M. Mickelson, M. Connor
	Seasonal patterns and controlling factors of primary production in Puget Sound's Central Basin and Possession Sound Technical Memorandum. September 2001	M. Mickelson, A. Keller
	Seasonal patterns and controlling factors of primary production in Puget Sound's Central Basin and Possession Sound: assessing the role of nutrient limitation. November 2002	M. Mickelson, A. Keller
	Brightwater Marine Outfall: Baseline Sediment Characterization Study – Sediment Chemistry and Benthic Infauna Final Report – November 2002.	M. Connor
	Baseline Sediment Characterization Study, Candidate Outfall Diffuser Sites, Sampling and Analysis Plans. September 2001	M. Connor
Risk Assessment	Phase 2 Marine Outfall Siting Water Quality Investigations. September 2001	M. Connor, M. Mickelson, P. Roberts
	Brightwater Marine Outfall: Phase 3 Water Quality Investigations. November 2002	M. Connor, M. Mickelson, P. Roberts
	Analysis of Human Use of Puget Sound Shorelines. September 2001	M. Connor
	Brightwater Marine Outfall: Human Use Survey of Puget Sound Shorelines. November 2002	M. Connor
	*** Partial review**	

4.0 FINDINGS AND RECOMMENDATIONS

This section presents a set of general recommendations from the panel, and a general bulleted summary followed by a comprehensive account of the panelist's primary findings and recommendations for the six core areas discussed at the May 1 meeting. The bulleted section addresses the five questions listed in the matrix chart, as well as general recommendations for report modifications. The comprehensive findings and recommendations represent the bulk of this section and address specific topics covered by each panelist during panel member presentations. Production of this section was made possible from an audiotape recording of the meeting, completed matrix charts, and notes taken by the peer review coordinator.

As a group of experts, the panel made the following recommendations to King County:

- Provide a context for the outfall within Puget Sound: For example,
    - f) *Outfall design and general observations*: put proposed outfall into context with existing outfalls in Puget Sound, as well as other outfalls in the United States, and overseas. How would it compare?
    - g) *Water quality*: put proposed outfall discharge in context with other loads entering Puget Sound (i.e., stormwater discharges, atmospheric and riverine inputs); seek information from the Total Maximum Daily Load (TMDL) process.
    - h) *Risk assessment*: compare numbers with other outfalls;
    - i) *Monitoring*: relate water quality and chemistry data to monitoring programs such as the Puget Sound Ambient Monitoring Plan (PSAMP) – seek a better conceptual framework; and
    - j) *Other data*: fit components of the biological studies into the larger Puget Sound picture. Also, put sediment data into context with the seafloor bathymetry, where sediments accumulate, and at what rates.
- Report that standards could be met with lesser levels of wastewater treatment, but that the proposed facility will exceed requirements by using secondary treatment with chlorination, and ultimately membrane filtering, an even greater level of treatment. Highlight long-term environmental goals of the proposed facility.
- Develop a summary report emphasizing the overall picture. Incorporate conclusions from the 28 technical documents and produce a 40 - 50 page report for the public. The report should be readable, understandable, and between a technical document and a public document in scope.
- Develop and submit manuscripts for publication in the peer-reviewed literature. For future work, consider producing reports targeted for peer-reviewed publication in addition to, or in lieu of, agency data reports.

> "There are two really good reasons: science really is only made of peer reviewed papers…and the gold standard is peer review by anonymous reviewers. Also, when you…write a real paper like that…you have to relate it to a real context…and you will have done the synthesis of ideas as opposed to something that looks like a data report…and the synthesis is

what will communicate to the public, to the policy makers, to everyone." [Parker MacCready, verbal comment from the May 1 meeting].

- Conduct further or improved analyses in several areas (e.g., biology, modeling, risk assessment) to address data gaps and strengthen existing data. Also, undertake additional studies such as forage fish spawning surveys and ichthyoplankton surveys; obtain continuous stratification measurements; develop methods consistent with the University of Washington's (UW) oceanographic methods; and better Method Detection Limits (MDLs) - particularly for organic contaminants.
- Improve data interpretation and reporting. State clearly in your reports what you are trying to accomplish and the rationale.

Refer to Appendix B for the full text written comments and the summaries of the reviewer's comments. All direct quotations encapsulated below are verbal comments from peer review presentations at the May 1, 2003 meeting.

4.1 Geology

Two primary technical documents and one short appendix, *Submarine Cultural Resources*, were reviewed for the geology portion of the MOSS. Refer to Table 1 for a list of the technical documents. The short appendix is not addressed in the bulleted section below.

- Were the study designs scientifically sound?
  - ***Yes***, the study designs for the technical documents were scientifically sound. The Detailed Evaluation Questions (DEQs) were clearly stated and followed.
- Were the study methodologies acceptable and appropriate?
  - ***Yes***, the study methodologies were acceptable and appropriate. The data met the DEQs.
- Were the data sufficient to meet the study purpose?
  - ***Yes***, the data were excellent.
- Did the reports adequately present study results?
  - The results for all studies were presented adequately ***except*** for the following observation:
    1. The reports were not commensurate with the data collected, and although it appeared the science supported the conclusions, the conclusions were not adequately documented in the reports (i.e., without detailed graphical support).
- Recommendations for report modifications:
  - Quality Assurance/Quality Control (QA/QC) procedures and the raw data should be presented in appendices. Accurate and quality data logs and figures are critical and should be added to the existing reports,
  - Better documentation and improved data presentation are needed,

- Place the outfall design criteria into context with other Puget Sound outfalls, and
- The multi-beam processing artifacts should be "cleaned."

Comprehensive Findings and Recommendations

1. Finding: The consultant team did address areas of concern regarding the outfall as outlined in the King County DEQ's. However, the specifications for the initial survey designs were not given, thus limiting the reviewer's ability to determine if appropriate scientific examinations were used to address study objectives.

The evidence of a "bird dog," or someone who monitors the methods of data collection and the acceptability of data, was lacking during the program. It was unclear whether this duty was assigned "in house" or at some King County level.

Recommendation: Append the specifications to each geology report, document the acceptability of data products, and specify the "bird dog" component.

2. Finding: The *Marine Geophysical Investigation: Marine Outfall Siting Study* and the *Brightwater Marine Outfall Conveyance System Interim Conceptual Geotechnical Assessment* reports did not adequately represent the quantity and quality of field data collected. The report's presentation lacked sufficient detail to convey how the data were edited and analyzed.

> "I felt the report was more of an operations review rather than a technical treatise of the data. I felt the QA/QC discussion was deficient. I wanted more information about how the data were treated and any problems encountered within the program. The conclusions within the report were made without detailed graphical support. There were not enough raw data in appendix form to help me formulate the conclusions that they came to" [D. Levin]

Recommendation: Add raw data sheets, detailed QA/QC procedures and data deliverables, in appendix form, to both reports. Document the type, range, and source of errors in the QA/QC appendices. In general, better documentation is needed. Also, specify how the data were handled and processed. Finally, improve the figures by "cleaning up" the data (e.g., cartographic inflections, renditions) that may cause a reader to see things that are not actually there.

> "My suggestions are in terms of improving the QA/QC and adding your data sheets to improve the presentation as it goes forward through future scrutiny." [D. Levin]

NOTE: Discussions at the May 1 meeting revealed that some of these data exist but were not available to the panelist prior to the review of the technical documents. These data may address some of the issues raised in the panelist's findings (i.e., raw data, QA/QC and specifications).

3. Finding: Scientific references were not cited for several selection criteria (e.g., rationale for selecting certain numbers was not given). The numbers were acceptable but not scientifically documented.

> "I did not see geologic references that supported the selection criteria presented in the DEQ's. I do not know the source of the 300 m, 20°, or 2% information, or how that information was created. I'm sure it is well founded, but if you have support for it, I did not see it, and I think that would be helpful." [D. Levin]

Recommendation: Specify the basis for the criteria used to evaluate site acceptability.

4. Finding: The geophysical and geotechnical methods and instrumentation were not completely described. Methods of post-processing side scan sonar data were not obvious. The processing of sub-bottom profiling data also was not clear. Finally, the method of independent GPS verification was not discussed.

Recommendation: Clearly describe all methods, equipment and instrumentation. Add methods and data to the appendices (e.g., electrical resistivity and refractometry data).

5. Finding: The *Brightwater Marine Outfall Conveyance System Interim Conceptual Geotechnical Assessment* report contained a very good treatise of seismicity in Puget Sound.

Recommendation: None.

6. Finding: A comprehensive submarine cultural resources report will be required after the final route is selected.

Recommendation: Include a licensed archaeologist during any cultural surveys, whether a requirement by the state of Washington or not. Utilize a magnetometer for close line spacing surveys.

4.2 Physical Oceanography

Three technical documents were reviewed for the physical oceanography portion of the MOSS. Refer to Table 1 for a list of the technical documents.

- Was the study design scientifically sound?
    - ***Yes***, the study design was well thought out.
- Were the study methodologies acceptable and appropriate?
    - ***Yes***, the study methodologies were acceptable and appropriate. "State-of-the-art."
- Were the data sufficient to meet the study purpose?

  - ***Yes***, extensive and detailed data sets were collected.
- Did the reports adequately present study results?
  - ***Yes***, the analyses were sound.
- Were appropriate resources and information reviewed and presented?
  - ***Yes***, the *Review: Puget Sound Physical Oceanography Related to the Triple Junction Region* report was comprehensive.
- Recommendations for report modifications (for the *Final Report: Puget Sound Physical Oceanography*):
  - Improve the Executive Summary by addressing the potential impacts from an outfall to Whidbey Basin (i.e., low dissolved oxygen (DO) in Whidbey Basin), and extrapolate the climate issues during the study period (i.e., dry study year and reduced freshwater river input).
  - Improve the flow schematic diagrams (Figures 95-98).

Comprehensive Findings and Recommendations

1. Finding: The *Review: Puget Sound Physical Oceanography Related to the Triple Junction Region* was excellent, a thorough report that covered all relevant documents.

Recommendation: None.

2. Finding: The *Interim Report: Puget Sound Physical Oceanography Related to the Triple Junction Region, Phase 2* and the *Final Report: Puget Sound Physical Oceanography* reflected the most extensive and intensive studies undertaken in any region of Puget Sound to date. Many measurements were made to produce a picture of the Triple Junction region's circulation.

> "I didn't have any important technical issues to raise with how the measurements were made or analyzed. My comments have to do with how they were interpreted, especially at the level of the executive summary." [P. MacCready]

Recommendation: None.

3. Finding: Data suggest Whidbey Basin suffers from low dissolved oxygen and stagnant water: a chronic water quality problem. Estuarine circulation is complex in the Triple Junction region; therefore what is the likelihood that effluent will be transported from the outfall site into Whidbey Basin?

> "A lot of my interest focused on the potential for sewage flowing up there…probably the only really worrisome issue of all the physical oceanography observations and their interpretation." [P. MacCready]

Recommendation: State clearly this possibility in the Executive Summary of the *Final Report: Puget Sound Physical Oceanography* document.

> "Whether or not the sewage outfall is likely to do that (send more organic matter that has oxygen demand or feed more nutrients into this part of the system), I doubt, but I think it is an issue that needs to be expressed explicitly as one talks about the physical oceanography results." [P. MacCready]

4. Finding: The flow schematic diagrams (figures 95-98) in the *Final Report: Puget Sound Physical Oceanography* are essential for communicating information to non-oceanographers and lay audiences. Figure 96 is especially important because it illustrates the mean flow at mid depth, the depth at which the diluted sewage plume is expected to rise and circulate northward to Possession Sound (Whidbey Basin).

> "There is a great deal of variability and complexity superimposed on top of this, but this figure does a good job of showing essentially anything from along any of these potential sites (outfall locations near Point Wells) is liable to get caught in this flow heading up to Whidbey Basin." [P. MacCready]

Recommendation: As stated previously, the Executive Summary should reflect explicitly the potential for flow into Whidbey Basin. To minimize potential effects, the effluent should be discharged near the surface to take advantage of the currents to more effectively distribute the effluent. It is understood, however, that this option may not be politically and/or publicly acceptable.

5. Finding: A dry winter study period most likely affected the estuarine circulation (e.g., reduced river flows into Puget Sound); thus, an extended residence time may have been measured.

Recommendation: This is an important observation and should be reported in the Executive Summary of the *Final Report: Puget Sound Physical Oceanography*.

4.3 Biology

Six technical documents were reviewed for the biology portion of the MOSS. Refer to Table 1 for a list of the technical documents.

- Were the study designs scientifically sound?
    - ***Yes***, the goals were clearly stated although the rationale was sometimes unclear (e.g., explain what is being attempted during each study).
- Were the study methodologies acceptable and appropriate?
    - ***Yes***, standard methods were used and the study variables were appropriate.
- Were the data sufficient to meet the study purpose?
    - All data for all reports were sufficient ***except*** for the following:
        1. The reviewer was unsure if data were sufficient for the Dungeness crab component in the *Biological Resources Report, Phase 2* (i.e., additional data are needed from other sources, such as WDFW catch records).

2. The spatial and temporal data for juvenile salmonids may be insufficient (i.e., reviewer unsure if sampling occurred over the entire calendar year, and if the number of sites were sufficient) in the *Brightwater Marine Outfall Phase 3 Biological Resources Report.*

- Did the reports adequately present study results?
  - The results for all studies were presented adequately ***except*** for the following:
    1. Insufficient detail for the food web section, and the Dungeness crab results were deficient due to sparse data in the *Biological Resources Report, Phase 2*.
    2. Potential statistical errors were observed, and the experimental design was incompletely described in the *Brightwater Marine Outfall: A Geoduck (Panopea abrupta) Survey for the King County MOSS*.
    3. Data presentation and reporting in the *Submerged Aquatic Vegetation Patterns in Candidate Outfall Zones*:

- Were appropriate resources and information reviewed and presented?
  - ***Yes***, the literature review was thorough for spot prawn data in the *Brightwater Marine Outfall Phase 3 Biological Resources Report*.
- Recommendations for report modifications (all technical reports):
  - In general: additional and better graphics, more statistics, additional data analyses; and improved data presentation (clarity). Also, explain more completely the experimental design for each report, and relate the results of the studies to the proposed outfall siting area and the overall health of Puget Sound.

  Specifically,
  - <u>*Biological Resources Report, Phase 2*</u>: Include and improve graphical illustrations; utilize new data for constructing marine food webs; obtain more Dungeness crab data; and explain the significance of the results to siting a new outfall.
  - <u>*Brightwater Marine Outfall Phase 3 Biological Resources Report*</u>: Explain the experimental design for the forage fish study; complete the beach seine study for juvenile salmonids and marine finfish (statistical approach); and initiate additional studies (ichthyoplankton and/or zooplankton).
  - <u>*Brightwater Marine Outfall: A Geoduck (Panopea abrupta) Survey for the King County MOSS*</u>: Correct statistical errors and transform data logarithmically (re-interpret data and report new results – issue an errata sheet to the existing report). Collect additional biomass data. Explain more completely the experimental design (i.e., statistics).
  - <u>*Submerged Aquatic Vegetation Patterns in Candidate Outfall Zones*</u>: Re-write the report to eliminate masking of data quality.

- *King County Marine Habitat Report Prepared in support of the Wastewater Treatment Division, Habitat Conservation Plan, and the Brightwater Marine Outfall Siting Study*: Include more graphical illustrations; re-plot fish distributions; and standardize maps.

Comprehensive Findings and Recommendations

1. Finding: The *King County Marine Habitat Report Prepared in support of the Wastewater Treatment Division, Habitat Conservation Plan, and the Brightwater Marine Outfall Siting Study* was mostly a literature review where a conscientious effort was made to gather existing information relevant to species and habitats, as well as identifying data gaps.

The habitat maps were adequate, especially the clear and readable format for marine bird distributions. The distribution and abundance data were, however, limited for juvenile salmonids and lamprey; also, the deep sub tidal habitat data were lacking.

Recommendation: Include graphical illustrations showing fish abundance for species such as Pacific cod, report units of measurement consistently, and specify seine net size and area fished.

Utilize the marine bird format when mapping salmonid and marine fish distributions (instead of what was used). Summarize salmonid fish data in tabular form, as was completed for the marine fish species.

2. Finding: Geoduck surveys were out of date and Dungeness crab conclusions were weak (because data were limited), as presented in the *Biological Resources Report, Phase 2*. The food web section was too general to satisfy the stated goals of providing species-specific information. Also, the method of site selection for forage fish egg surveys was not fully explained.

Recommendation: Incorporate additional Dungeness crab data from sources such as WDFW commercial and recreational catch reports. Describe the rationale for excluding survey areas or modifying protocols during forage fish egg surveys.

3. Finding: Phase 1 and 2 biological results were adequately presented in the *Brightwater Marine Outfall Phase 3 Biological Resources Report*. The experimental design for the forage fish egg study, however, was not fully explained, nor was the significance of findings to candidate outfall sites.

> "I thought the experimental design could have often benefited from additional explanation. I like to see an experimental design phrased in terms of statistics, a randomly-selected series of stations where you are doing a comprehensive coverage of the entire area." [A. Keller]

<u>Recommendation</u>: Initiate a quantitative sampling design.

> "Determine if differences do exist in the forage fish egg densities among the remaining candidate sites. If you really want to address the area where you're going to minimize the impact to forage fish…you can do a quantitative sampling with a grid transect, and that method has already been developed by WDFW." [A. Keller]

4. <u>Finding</u>: The objectives for the beach seine study were excellent, although not yet reached: a forthcoming report will examine the fishery data in more detail (statistical approach). Therefore, the beach seine study results are preliminary. The fish species include juvenile salmonids and other marine finfish.

<u>Recommendation</u>: Complete the fish stomach content analyses, coded wire tag analyses and present fish length data. If fishery data from the beach seine surveys are available for an entire annual period then these data should be graphed over that cycle. Once the stomach content analyses are completed, use the data to improve the food web discussion.

5. <u>Finding</u>: Data gaps were identified for spot prawn distribution and abundance and ichthyoplankton and zooplankton.

<u>Recommendation</u>: Address data gaps for both with one sampling effort.

> "You'll get [larval] spot prawn information at the same time, and you might want to do both surveys at the same time and same places, with two different [net] mesh sizes." [A. Keller]

6. <u>Finding</u>: There appeared to be an error in the data analysis of the *Brightwater Marine Outfall: A Geoduck (Panopea abrupta) Survey for the King County MOSS* report. Specifically, geoduck count and density data from two transects were incorrectly assigned to the wrong sub area, producing results that may be erroneous.

> "The results do change from 'no significant difference in abundance between subareas,' to 'there are significant differences with higher abundance.' And more importantly, the results also change from 'there is no significant differences in the MOSS sites' to 'there being differences in the MOSS sites with greater abundance of geoduck in Zone 5,' which seems to be out of the running right now anyway, but there is some information to suggest a reason for that." [A. Keller]

<u>Recommendation</u>: Check for errors and then correct; logarithmically transform the data; re-do the statistical analyses; and report the new results. Issue an errata sheet to the existing report.

7. <u>Finding</u>: The experimental design produced a thorough assessment of geoduck abundance. However, the method of sampling a subset of transects for geoduck biomass resulted in only one biomass plot.

<u>Recommendation</u>: Modify the sampling technique to increase the number of biomass samples spread across the geoduck transects.

8. <u>Finding</u>: The *King County Nearshore Habitat Mapping Data Report: Picnic Point to Shilshole Marina* (*Nearshore*) was an excellent study overall.

> "This was one of those reports that you read and it was just easy to read, it was pleasant to read, it was well done, it was well thought out, it was well carried out, it was well presented. We both felt it might be a keystone report…others should be modeled after it." [A. Keller (with co-reviewer D. Levin)].

<u>Recommendation</u>: None.

9. <u>Finding</u>: Though objectives were similar, the methods used in the *Submerged Aquatic Vegetation Patterns in Candidate Outfall Zones* (*SAV*) report differed from those used in the Nearshore study. Some of the suggestions from the earlier *Nearshore* report were not incorporated in the *SAV* study (e.g., failed to survey during the recommended summer sampling period). Deficient reporting masked the quality of the data.

<u>Recommendation</u>: Re-write the *SAV* report if the writing style interferes with data interpretation.

> " I think you need to go out in the final zones, whatever you come down to, and take a detailed look at where these eelgrass and kelp beds are located and particularly look at these corridors they've identified and make sure they are corridors during the summer as well as the spring and fall." [A. Keller]

10. <u>Finding</u>: The Habitat Conservation Plan (HCP) for the county's wastewater treatment division covers 23 species

<u>Recommendation</u>:

> "Of those, which are most relevant to this discharge with the outfall. If there is a way you could develop a matrix that said 'OK, well then we're going to pay most attention here,' then you'd have some sense that answers your questions." [M. Connor]

> "This is probably the most important point: relate the gathered [biological] information to the overall health of the species of Puget Sound, and since all this information was gathered to put together an HCP, then relate the information to that as well." [A. Keller]

4.4 Hydrodynamic Modeling

Three technical documents were reviewed for the hydrodynamic modeling portion of the MOSS. Refer to Table 1 for a list of the technical documents.

- Were the study designs scientifically sound?
  - ***Yes***, although the mixing zone terminology was not clearly defined.
- Were the study methodologies acceptable and appropriate?
  - ***Yes***, although too few density profiles and currents were used in initial dilution simulations.
- Were the data sufficient to meet the study purpose?
  - All data for all reports were sufficient ***except*** for the following:
    1. Insufficient density profile (stratification) data in near field modeling.
- Did the reports adequately present study results?
  - The results for all studies were presented adequately ***except*** for the following:
    1. Insufficient discussion of the statistical distribution of rise height and dilution,
    2. Inadequate reproduction of mean currents and stratification by the Princeton Ocean Model (POM), and
    3. Intermediate modeling on time scales of a few hours not represented.

- Recommendations for report modifications (all technical documents):
  - Obtain continuous measurements of density stratification in order to better characterize the statistical distribution of dilutions. Display a range of numbers versus bracketed high/low figures (i.e., worse-case scenarios).
  - Improve modeling and analysis of near field behavior,
  - Better assessment of onshore transports,
  - Provide raw data for density profiles, current speeds,
  - Discuss wastewater behavior in understandable terms, i.e., submerged plume unlikely to come to shore, high dilutions.
  - Discuss trade-offs with outfall design (diffuser versus open pipe; treatment levels).

Comprehensive Findings and Recommendations

A general description of effluent plume activity near a diffuser:

> “The density of sewage is very close to freshwater so when discharged into the marine environment it is very buoyant; it starts rising up very quickly and as it rises it forms an intense turbulence zone resulting in very rapid mixing very close to the diffuser. Another important thing is the effect of stratification whereby typically you have the warmer, less dense water near the surface, and colder,

> denser water near the bottom so you have a density stratification. That's really important because that can stop the rising plume and trap the whole plume below the water surface. The dilution and rise height depends on the current speed, the current direction relative to the diffuser, the stratification, etc. Generally speaking, in terms of outfall design, it's usually desirable to get a submerged plume because then the probability of this coming to the shore is much reduced – and you don't have any direct sight of it on the water's surface. So, in the region very close to the diffuser, usually called nearfield mixing, we can get dilutions of 100:1 or even higher very quickly, within a few minutes. That turbulence then collapses and the plume starts to drift under the effect of the ocean currents and the mixing and diffusion in that region proceeds at a much slower rate. And that's often called the far field." [P. Roberts]

1. Finding: The near field modeling contained insufficient density profile data (i.e., stratification data), and few current speeds were used in the simulations. Details such as the effect of the shape of the density profile on effluent plume rise height is very important as it affects the ultimate fate of the plume, and was insufficiently addressed.

> "The major point here is that because planes of density in the sound tend to be roughly horizontal, then once the plume is trapped it stays trapped, and it doesn't come to local beaches. Whether it does or not depends on vertical mixing…which is very slow because of the stratification … In other words, it's extremely unlikely that the plume is going to come to shore." [P. Roberts]

The effect of the rise height on flushing was another component that was not adequately addressed in the reports.

> "… Presumably the objective here is to flush the mixed wastewater out of the sound as soon as possible, but the flushing current varies with depth; higher velocity at the surface, decreases to zero at some depth and then starts to flow inwards at the bottom…So, if that's the case, then your objective is to try to get this up near the surface as possible to flush it out as quickly as possible. But the disadvantage to that of course is that if you get too close to the surface then the probability of it coming to shore increases. So there are some tradeoffs there, which really were not discussed in the reports." [P. Roberts]

Recommendation: Provide the raw data on which density profiles were based; include plots of the current speed raw data (current speed versus time); and explain more completely the procedures for deriving the mean density profiles.

> "Use time series of currents and stratifications directly in the near field modeling. In other words, not just choose a few representative currents and stratifications, instead use all the data … Then, instead of saying things like "the dilution is 100:1"… come up with some statistical estimates of the near field zone - the length of mixing zone, the frequency distribution of dilution rise height, etc. And do this on a statistical basis rather than a few isolated points." [P. Roberts]

2. Finding: Short-term modeling of the near field and the long-term time scale modeling were done, but intermediate time scale modeling (on tidal time scales) was mostly absent.

> "And that's important because usually the biggest impacts locally come from transports on the times of a few hours or so." [P. Roberts]

Recommendation: Capture the intermediate time scales with additional modeling.

3. Finding: Onshore transports were insufficiently assessed.

Recommendation: Improve the assessment of onshore transports by using a smaller grid size with the existing POM, or advective transport modeling using the current meter data, or both.

> "I think using the POM model results to predict average dilutions at the shoreline is misleading; it gives a much more pessimistic prediction of the plume coming to shore." [P. Roberts]

> "I read that [report] as well and found the diffusion results of the POM model to be very difficult to absorb. I think a picture would have helped a lot." [P. MacCready]

4. Finding: None of the modeling completed thus far has demonstrated the need for advanced levels of wastewater treatment to meet water quality or health standards.

> "I would say there is no scientific basis in any of these reports to justify advanced level of treatment – meaning secondary treatment." [P. Roberts]

Recommendation: Consider the trade-offs of treatment and diffuser when designing the outfall. What level of treatment is needed to achieve the standards?

5. Finding: The oceanographic investigations were excellent but could have been more closely linked to the modeling efforts (i.e., on a smaller scale).

> "There is a lot of good stuff in there that really wasn't used. They did a lot of dye tests, drogue movements – tells you a lot about where the plume is going to go. But it really wasn't used anywhere." [P. Roberts]

Stratification data near the diffuser areas were lacking; specifically, continuous stratification data.

> "There was one period back in the 1970's when the stratification completely disappeared in Puget Sound because of a combination from environmental conditions…I guess it's worth noting what could happen with a "no stratification" scenario." [P. MacCready]

Recommendation: Incorporate more of the oceanographic data into the modeling, and collect additional continuous stratification data.

NOTE: The King County MOSS team is planning to collect additional density stratification data (continuous measurements) in the near future.

6. Finding: Several terms were used in the *Initial Dilution Assessment of Potential Diffuser Zones, MOSS Plume modeling: Continuous discharges to Puget Sound, Phase 2* report; the *Brightwater Marine Outfall Phase 3 Initial Dilution Assessment of Potential Diffuser Zones* report; and the *Brightwater Marine Outfall: Puget Sound Marine Modeling Report* when referring to Mixing Zones. The terminology was not clearly defined for any of these (e.g., zone of initial dilution, near field, regulatory mixing zone).

> "There are no unique, generally-agreed definitions but at least the way they were used in the report should be defined better. And it's important…because whether you meet the dilution requirements or not depends on how you define the near field. Where is it? It makes a huge difference." [P. Roberts]

Recommendation: None.

4.5 Chemistry

Nine technical documents were reviewed for the chemistry and water quality portion of the MOSS. Refer to Table 1 for a list of the technical documents.

- Were the study designs scientifically sound?
    - ***Yes***, the study design for the technical documents was scientifically sound; "complex."
    - The Washington state sediment standards may be inappropriate.
- Were the study methodologies acceptable and appropriate?
    - The methodologies were acceptable and appropriate for all studies ***except*** for the following:
        1. The method detection limits for organics were insensitive for the *Brightwater Marine Outfall Baseline Sediment Characterization* report. Consider re-evaluating, or adjusting, the methodology (i.e., modify the MDLs).
- Were the data sufficient to meet the study purpose?
    - ***Yes***, detailed, long-term data sets exist; 30-year water quality sets in some cases.
- Did the reports adequately present study results?
    - ***Yes***, all reports adequately presented study results. Strive for more multi-year trends, and discuss sediment process (locations and rate of accumulation).
- Recommendations for report modifications:
    - Relate data to PSAMP,

- Further synthesize data from the *Water Quality Status Report for Marine Waters, 1999 and 2000*, and the *Water Quality Status Report for Marine Waters, 2001*,
- Need a Puget Sound conceptual framework - recognize that an iterative process may identify new or different data needs within a set framework.
- Need better detection limits in the effluent. Consider new contaminants of concern (i.e., lipophilic pesticides, PCBs, dioxins, estrogen mimics).
- Put sediment data into context with the sound-wide distribution of sediments (link with PSAMP),
- Temporal trends.

Comprehensive Findings and Recommendations

1. Finding: The *Water Quality Status Report for Marine Waters, 1999 and 2000*, and the *Water Quality Status Report for Marine Waters, 2001* (*Status Reports*) are good data reports, as well as good evaluation of compliance.

> "The data are so good they deserve more synthesis. The more you synthesize it, the more you find problems in the data – and then you fix the data quality problems … Feedback is essential, and I think you're in real danger if you do not do that. That is the main reason why this stuff has to get out into the [peer reviewed] literature … Synthesis reports increase the utility and acceptance of the monitoring program, the marine outfalls, and siting decisions." [M. Mickelson]

> "The *Status Reports* need to better explain how the monitoring data relate to the management questions for the Sound. The National Academy of Sciences has developed a general rule of thumb for monitoring that recommends you should spend half your money on data collection and half your money on data analysis, and nobody does that. While I'm not aware of any monitoring program that meets that standard, every program could use more data synthesis. Data synthesis is always the easiest thing to cut in the budget. But the reason you are collecting data in the first place is to learn if the management decisions are the correct ones." [M. Connor]

Recommendation: Develop synthesis reports of some elements. For instance, synthesis reports on the following topics, ranked in order of importance, should be pursued: a) explaining the continued use of methods producing frequent non-detects (less than the MDLs), b) listing new contaminants of concern, c) clearly illustrating multi-year trends, d) better use of the existing oceanography, including an oceanographic context, and e) relating the data to other monitoring programs such as PSAMP.

> Regarding MDLs - "You need to use the same detection limits as the University of Washington, particularly for nutrients. You need better detection limits in the effluent for those contaminants that can be found at concentrations above water

> quality standards. The quality of the detection limits should not drive the conclusions in the risk assessment report." [M. Connor]

2. Finding: The monitoring stations in the *Status Reports* did not extend to the Whidbey Basin. As discussed in the physical oceanography section, this area experiences depressed DO levels – symptomatic of a chronic water quality problem.

Recommendation: Consider a study in Whidbey Basin to gain a better understanding of the processes at work - additional monitoring stations and conductivity/temperature/density (CTD) transects.

3. Finding: The monitoring data from the *Status Reports* (and other MOSS reports) were not linked to the environmental indicators listed in monitoring reports such as the Puget Sound Action Team's *2002 Puget Sound Update*. Examples of indicators listed in the *2002 Puget Sound Update* but not covered in the Status Reports included PCBs and dioxins.

Recommendation: Use the PSAMP to improve the coordination between monitoring programs in Puget Sound.

4. Finding: The data collected for the *Seasonal patterns and controlling factors of primary production in Puget Sound's Central Basin and Possession Sound Technical Memorandum* and the *Seasonal patterns and controlling factors of primary production in Puget Sound's Central Basin and Possession Sound: assessing the role of nutrient limitation* (*Primary Productivity*) reports were especially important since historical data are limited in this region of Puget Sound.

Recommendation: The report authors should publish their findings in the peer-reviewed literature. Also, develop a baseline for productivity in this region of Puget Sound for which to measure future impacts.

5. Finding: The *Primary Productivity* reports contained depth-integrated data but lacked depth-specific data.

> "As readers we couldn't pursue it because [the report] only gave depth-integrated productivity. We need to see hourly, because it looked like there were unbelievably high values." [M. Mickelson]

Recommendation: Include the depth-specific data in both *Primary Productivity* reports.

6. Finding: It was not known whether the true rate of production is overestimated (higher that the theoretical limit) or underestimated.

> "These are really some of the highest productivity rates in the world." [A. Keller]

Recommendation:

> "The report should not imply that the proposed outfall could increase the nutrients appreciably. It therefore has little to do with outfall siting." [M. Mickelson, from presentation slide]

7. Finding: Insensitive method detection limits for organics were used in the *Geoduck Tissue Physical Characteristics, Microbiology, and Chemistry: Geoduck Tissue Study for the Brightwater Marine Outfall*.

Recommendation: Consider using more sensitive detection methods in this study (e.g., for PCB concentrations). Mussel sampling elsewhere, such as in Tomales Bay CA, consistently generates detectable PCB levels at lower limits than what was reported in this study.

8. Finding: The state of Washington's sediment protocols require collecting 10 cm depth for a baseline sediment characterization.

Recommendation: Consider refining the sediment depth standard (e.g., sample the top 3 cm).

> "If the rate of sedimentation is only a few millimeters per year, you're never going to see a measurable change in your lifetime when you only sample the 10 cm of sediment. If you're looking for an effect of an outfall, you need as good a sample of freshly sedimented material as possible." [M. Connor]

9. Finding: Sediment data from the *Baseline Sediment Characterization Study for the Brightwater Marine Outfall* were not presented in any larger context.

Recommendation: Characterize the outfall's organic contaminant load contributions to the total sediment reservoir currently present in Puget Sound. Provide some comparison so people can better understand what is happening. This is especially important because of the concern over contamination (e.g., PCBs and dioxin) of marine animals and fish. Improve the sediment detection limits for organics.

> "It would be helpful to the reader to present the sediment data, not only in context to the standards…but in the context of what the sediment process are, how it relates to the bathymetry, where are the sediments accumulating, and whether there are different sedimentation rates in different areas." [M. Connor]

Also put the sediment data into context with the Puget Sound-wide distribution of sediments. How does the sediment data fit into the contaminated sediments throughout Puget Sound? Monitoring programs such as PSAMP use contaminated sediments as an indicator.

4.6 Risk Assessment

Four technical documents were reviewed for the risk assessment portion of the MOSS. Refer to Table 1 for a list of the technical documents.

- Were the study designs scientifically sound?
    - ***Yes***. Although the risk assessment used standard EPA methodology, it failed to guide the reader toward the pertinent and important issues associated with other marine outfalls around the country. For example, the risk assessment focused attention on chemicals not normally associated with marine outfalls, as well as unlikely exposure pathways (i.e., swimming ingestion versus consuming contaminated shellfish).

        "This failure was partially due to analytical chemistry detection limits issues, partially due to the limitations of hazardous waste risk assessment techniques, and partially due to the evolution of methodologies employed for endangered species assessments. These latter methodologies are usually negotiated on a case-by-case basis, so it may be necessary to do additional assessments in the future." [M. Connor]

- Were the study methodologies acceptable and appropriate?
    - ***Yes***, although better detection limits for organics are needed. Also, consider a Monte-Carlo approach to capture a range versus the worse case assumptions.
- Were the data sufficient to meet the study purpose?
    - ***Yes***, the data were sufficient to meet the study purpose.
- Did the reports adequately present study results?
    - ***Yes***, the reports adequately presented study results.
- Recommendations for report modifications:
    - Utilize a risk assessment approach that is better suited to marine outfalls.
    - Put data into context with other outfalls, and other loads (e.g., PCBs),
    - Re-evaluate the approach to see if the appropriate Puget Sound marine issues are being discussed.
    - Show the density and distribution of the fecal coliform data,
    - Re-evaluate the use of conservative assumptions and cancer risks,
    - Utilize more of the whole effluent toxicity testing,
    - Consider more fully the issue of estrogen mimics.

Comprehensive Findings and Recommendations

1. Finding: The *Analysis of Human Use of Puget Sound Shorelines, Phase 2* report and the *Results of Human Use Survey of Puget Sound Shorelines* report were comprehensive and well done. The seafood consumption information as related to risk assessment was helpful.

Recommendation: None.

2. Finding: The risk assessment used for the *Phase 2 Marine Outfall Siting Water Quality Investigations* report and the *Phase 3 Brightwater Marine Outfall Water Quality Investigations* report (*Water Quality Investigations*) was more of an EPA standard risk assessment, and focused on issues and concerns not customary to marine outfall discharges.

> "It overstated risks of things that were rarely considered to be problems in outfall discharges and it understated risks (due to high detection limits) of persistent organic pollutants that people commonly consider. These issues are bound to arise in a Section 7 Consultation … and you don't have enough data with appropriate detection limits to respond to those issues. Based on my experience and San Francisco, I believe you will find PCBs in your effluent and dioxins at concentrations greater than 1 ng/l, with a rough equivalency of dioxin in Toxic Equivalency units." [M. Connor]
>
> "Most of the literature in risk management says people are more afraid of risks they are unfamiliar with than the risks they know about." [M. Connor]

Recommendation: Get a good idea what you have, as far as risks, before you proceed into a risk assessment with detection limits that will be constraining (i.e., you are stuck with certain numbers).

3. Finding: Conservative methods and assumptions were used for this risk assessment (both *Water Quality Investigations* reports). The worse case scenarios could ultimately be accepted as the average case scenario and negatively affect, among other things, the endangered species risk assessment.

Recommendation:

> "In explaining the risk findings, I would quickly sort the data by only addressing the chemicals that are above water quality standards. I would make another sort of the data that are less that ten times greater than water quality standards, and then 100 times greater than water quality standards. This would allow the reader to easily focus on the handful of chemicals that require a more detailed analysis." [M. Connor]

4. Finding: Context with other issues was not highlighted. This risk assessment approach prevented the evaluation of outfalls in the context of indicators currently used in Puget Sound (e.g., those indicators reported in *2002 Puget Sound Update*). Also, it was not clear if the proposed outfall was new, or the first of its kind, or an addition to others in Puget Sound.

Recommendation: Put into context with existing outfalls in Puget Sound. Also put this outfall into context with other outfalls in the country, as well as around the globe. How are other outfalls behaving? What are the numbers and how does this outfall compare? Put the wastewater discharge into context with all the other loads entering Puget Sound.

> "As a novice to the Puget Sound region, the first thing I'd want to know about the proposed outfall would be how its inputs of BOD, solids, nutrients, and the top five toxic contaminants compare to the total amount of these materials reaching Puget Sound through anthropogenic and natural inputs." [M. Connor]

5.0 SUMMARY

Scientific peer review of the 28 technical documents from the Marine Outfall Siting Study produced a comprehensive set of findings and recommendations by the six-member panel of independent marine experts. The panel's findings and recommendations were offered by means of technical written comments, and presented later at the project-concluding meeting on May 1, 2003. Overall, the scientific investigations reported in the technical documents were acceptable, but some studies require additional or better scientific data as well as improved data presentation and reporting.

An independent scientific peer review process is critical. The panel offered valuable advice and lessons learned from past experiences with outfall projects, such as design and permit concerns, and recommending additional scientific studies. This fresh perspective to the technical issues will assist King County both in terms of the quality of the science, and public acceptance, as the outfall portion of the *Brightwater* Treatment Plant project moves forward.

6.0 NEXT STEPS

The Project Manager for the outfall component of *Brightwater* explained that the findings and recommendations presented by the review panel in Section 4.0 will help to guide the KCDNRP as the outfall portion of the *Brightwater* project moves forward with additional studies, pre-design of the outfall, and permitting requirements.

Input from the review panel regarding data presentation and document content will be incorporated into forthcoming documents produced as part of future studies. Additional scientific studies that are either ongoing, or proposed, include:

- A focused eelgrass survey along the proposed alignment route,
- Completing data analysis and the report for the nearshore beach seining surveys,
- Conducting an intertidal biota survey along the preferred alignment route,
- Additional geotechnical work along the preferred alignment,
- Polychlorinated biphenyl (PCB) mass balance and bioaccumulation modeling; low level PCB sampling in the water column,

- Ambient monitoring for endocrine disruptors and participation in national surveys for effluent,
- Additional sediment chemistry sampling along the proposed alignment routes,
- Continuous water column stratification measurements in the vicinity of the diffuser for the preferred alignment, and
- Additional plume and transport modeling.

In addition, recommendations regarding specific items for the 28 documents reviewed as part of this evaluation will be implemented by KCDNRP. The response to the findings and recommendations provided by the review panel are addressed by KCDNRP in a separate memorandum.

This *Peer Review Evaluation* document will be incorporated into the final environmental impact statement (EIS) for the *Brightwater* wastewater treatment project.

APPENDIX A

CURRICULUM VITAS

Appendix A-1

Michael Stewart Connor

Overview

My education and experience have been focused on improving the scientific basis of environmental policy formulation. Since 1983, I have overseen approximately $50 million of scientific studies as a project manager, program manager, and line manager. I combine a unique background of doctoral training in marine ecology and post-doctoral training in public health with fifteen years experience in regulatory affairs.

Education

B.S. Biology (with Distinction) Stanford University - 1974 (Phi Beta Kappa)

Ph.D. Biological Oceanography, Woods Hole Oceanographic Institution/MIT - 1980

Research Fellow, Interdisciplinary Programs in Health at the Harvard School of Public Health. (1981-1983)

> Evaluated the environmental health risks of toxic constituents in sewage sludge disposed on land, in the ocean, and in the air (through incineration).

Relevant Experience

Executive Director, San Francisco Estuary Institute (2002-present)
The San Francisco Estuary Institute is a non-profit science institute funded through grants, contracts, and discharge fees. Its mission is to foster development of the scientific understanding necessary to enhance and protect the San Francisco Estuary, through monitoring, research, and communication.

Vice President, Programs and Exhibits, New England Aquarium (1998- 2002)
The New England Aquarium is one of the oldest non-profit aquaria in the country with an annual budget of approximately $25 million. I oversaw the departments that create all the Aquarium's exhibits and conservation, education, and research programs.

Director, Environmental Quality Dept., Massachusetts Water Resources Authority (1988 - 1998)
The Environmental Quality Department (approximately 75 people, annual budget of $7.5 million) is comprised of three units --- Harbor Studies, NPDES Compliance Program, and Central Laboratory. The department evaluates the impact of cleanup efforts on the environmental health of Boston Harbor and Massachusetts Bay; evaluates compliance with the Authority's NPDES permits, coordinates the data reports received from environmental laboratories with the information needed for permit reporting and compliance and provides for the Authority's environmental analytical needs. I developed the harbor and bay monitoring program for MWRA to address public regulatory

concerns. I am responsible for translating those detailed technical studies into policy options for MWRA's Board of Directors.

Japan Society Public Policy Fellow (1997)
Summer fellowship at the Research Institute of Wastewater Management comparing watershed management in Japan and the United States.

Principle Research Scientist, Battelle Ocean Sciences (1986-1988)
Managed contractor assistance for EPA Office of Marine & Estuarine Programs for developing estuarine cleanup programs nationwide. Conducted environmental assessments at Superfund sites for industrial and governmental clients.

Bays Program Coordinator, EPA Region 1 (1983-1986)
Project leader for multi-million dollar program in Long Island Sound, Narragansett Bay, and Buzzards Bay for development of comprehensive pollution management programs. Also provided chief technical oversight for development of water quality standards for toxic substances and model development for waste load allocations. Provided biological review of secondary treatment waiver application for Boston Harbor. Assisted in drafting a section of the proposed ocean incineration regulations.

NSF Science for Citizens Public Service Science Fellow, Amity Fndn. (1980-1981)
Developed information on water management techniques for small farmers in Lane County, Oregon, and disseminated that information through popular articles, conferences, workshops, and site visits.

Co-Instructor, Shoals Marine Lab, Isles of Shoals, Cornell University. (1982)
Taught part of intensive summer course on marine pollution.

Co-director, Institute for Local Self reliance (1974-1975)
Developed information on urban food systems for this Washington, D.C. Policy/consulting group.

English Teacher, Pool Moo Agricultural High School, Hongseong, Korea (1972-1973)
Taught 5 classes daily as a member of Volunteers in Asia, Stanford University.

Professional Societies

Ecological Society of America: Certified Senior Ecologist 1989
Estuarine Research Federation
New England Estuarine Research Society
Water Environment Federation
American Society of Limnology and Oceanography (family)

Advisory Board Activities

Nominee, EPA Science Advisory Board, Washington, D.C. (1997)

Vice-chair, Association of Metropolitan Sewerage Authorities Water Quality Committee.(1997)

Visiting Committee, Chief Scientist, Ocean Assessment Division, NOAA. (1995)

Participant, National Research Council Committee on Science and Coastal Policy.(1995)

Member, MIT NOAA Sea Grant Advisory Board. (1990-)

Advisory Board, UMASS Boston, Environmental Sciences Program. (1988)

Board of Directors, North and South Rivers Watershed Association. (1988-1990)

Rapporteur, CEQ Panel on Long-Term Environmental Research and Development.(1985)

Member, EPA OWRS Advisory Committee on Municipal Sludge - Ocean Dumping. (1982)

Participant, National Research Council Workshop on Land, Sea, and Air Options for the Disposal of Industrial and Domestic Wastes.(1983)

External advisor for development of ocean incineration regulations, EPA Criteria and Standards Division.(1983)

Expert testimony on biological impacts of incineration of hazardous wastes in the Gulf of Mexico for the Gulf Coast Coalition. Testimony cited in recent report by Office of Technology Assessment.(1983)

State Reviewer for DOE Appropriate Technology Grants Program. (1982)

Panel member, NJ Sea Grant Site Review. (1985)

Consulting Activities

Prepared feasibility study on the cage culture of trout on tribal lands for the Abenaki Self-Help Association Inc. Represented ASHAI in meetings with the Vermont Departments of Environment, and Fish and Wildlife. (1978-1980)

Prepared report on monitoring strategies to determine the effects of offshore oil drilling on Georges Bank planktonic communities for the Ecosystems Center, MBL, Woods Hole, MA (1980)

Multi-Media Experience

NOAA Coastal Oceans Program Status and Trends Webpage. "Ask the Experts"
http://sotcpreview.nos.noaa.gov/bulletins/html/ccom_05/expert.html

Discovery Channel, interview, "The Hidden Boston"

Dozens of Boston news TV interviews.

Various WBUR interviews.

Various cable shows.

Various radio call-in programs.

Publications

Marine Ecology and Chemistry

Connor, M.S. 1984. Fish-sediment concentration ratios for organic compounds. Environmental Science and Technology 18:31-35.

Connor, M.S. and R.K. Edgar. 1982. Selective grazing by the mud snail *Ilyanassa obsoleta*. Oecologia 53:271-275.

Connor, M.S., Teal, J.M., and I. Valiela. 1982. The effect of grazing by mud snails, *Ilyanassa obsoleta,* (Say) on the structure and metabolism of a benthic algal community. Journal of Experimental Marine Biology and Ecology 65:29-45.

Connor, M.S. 1980. Snail grazing effects on the composition and metabolism of benthic communities and subsequent effects on fish growth. Ph.D. Thesis. Massachusetts Institute of Technology, Boston, MA

Connor, M.S. 1975. Niche apportionment among the chitons *Cyanoplax hartwegii* and *Mopalia muscosa* and limpets *Collisella limatula* and *Collisella pelta* under the brown alga *Pelvetia fastigiata*. The Veliger 18 (Supp.):9-17.

Connor, M.S. 1985. Comment on “Fish/sediment concentration ratios for organic compounds”. Environmental Science and Technology 19:199.

Connor, M.S. 1985. Summary report of the expert panel meeting on geochemical and hydrologic processes and their protection Pp. III-1-10 In: Report on Long-Term Environmental Research and Development. Council on Environmental Quality, Washington, D.C.

Connor, M.S. 1985. Review of “Effects of Pollutants at an Ecosystem Level”. Soc. Sci. Med. 20(7): 763-768.

Risk Assessment

Connor, M.S. 1984. Comparing the public health risk of fish contamination and ground water contamination by organic compounds. Environmental Science and Technology 18:628-631.

Connor, M.S., Werme, C.E., and K.D. Rosenmann. 1985. Public health consequences of chemical contaminants in the Hudson-Raritan estuary. Chapter 7 *In:* Priority Pollutants of the Hudson-Raritan Estuary. NOAA: Washington, D.C.

Connor, M.S. 1989. Estimating the public health risk of organic carcinogens in fish. Chapter 18 *In:* Marine Waste Management: Science and Policy (M. Champ and P.K. Park, eds.) Wiley: New York.

Connor, M.S. 1983. Assessing the risks of different waste disposal options to public health. Pp. 187-194 *In:* Background Papers for the Workshop on Land, Sea, and Air Options for the Disposal of Industrial and Domestic Wastes. National Research Council, Washington, D.C.

Connor, M.S. 1985. Comment on "Comparison of the carcinogenic risks from fish vs. groundwater contamination by organic compounds." Environmental Science and Technology 19:645-646.

Ozkaynak, H.M., Thurson, G., Connor, M., Spengler, J., Smith, M., Tong, E., Chelardi, R., and G. Sanford. 1984. Assessment of environmental impacts and public health risks associated with fossil energy technologies. Proceedings 6th International conference on Alternative Energy Sources, 12-14 December, 1983.

Environmental Monitoring

Connor, M.S. and L. Sommaripa. 1997. Tightening the relationship between monitoring and pollution abatement: The MWRA Contingency Plan. Marine Pollution Bulletin 34(1):9-14.

Connor, M.S., Werme, C.E., Boehm, P.E. and J.M. Neff. 1992. A decision framework for site management and site monitoring at ocean dumping sites. *In:* Proc. 7th International Ocean Dumping Symposium Series. Wolfville, Nova Scotia, Canada. J. Wiley and Sons, New York.

Fitzpatrick, J.J., DiToro, D.M., Isleib, R.R., Connor, M.S., and W.S. Leo. 1996. Boston Harbor Wastewater Treatment and Outfall Relocation: Tools for Evaluating Environmental Impact. *In:* Estuarine and Coastal Management—Tools of the Trade. Proceedings of the 19th National Conference of the Coastal Society.

Connor, M.S. 1992. Remote sensing as a marine monitoring tool: The local perspective. Pp. 281-291 *In:* Proceedings, First Thematic Conference on Remote Sensing for Marine and Coastal Environments, New Orleans, LA, 15-17 June 1992.

Connor, M.S. 1984. Monitoring sludge-amended agricultural soils. BioCycle 25(1):47-51.

Connor, M.S., Mickelson, M.J., and K.E. Keay. 1994. Wastewater discharge to Massachusetts Bay: Environmental monitoring changes the problem definition. Pp. 469-480 *In:* Proceedings of the Water Environment Federation 67th Annual Conference and Exposition: Volume IV, surface Water Quality and Ecology. Water Environment Federation, Alexandria, VA.

Environmental Policy

Levy, P.F. and M.S. Connor. 1992. The Boston Harbor cleanup. New England Journal of Public Policy 8(2): 91-104.

Connor, M.S. 1997. Comparing Water and Wastewater Treatment in Boston to Tokyo. Tokyo Metropolitan Government News (in Japanese).

Connor, M.S. 1995. The Boston Harbor Case: Management and Science. Pp. 251-259 *In:* Improving Interactions Between Coastal Science and Policy: Proceedings of the Gulf of Maine Symposium. National Research Council, Washington, D.C.

Connor, M.S., Leo, W.S., Keay, K.E. In press. Harbor Sediment Science and Wastewater Management. In Sediment Processes in Boston Harbor. MIT Sea Grant Press. 17 Pp.

Connor, M.S., Rex, A.C., Mickelson, M.J., Keay, K.E., and, W.S. Leo. In press. MWRA's Massachusetts Bay Outfall. Environment Cape Cod 1(3):

Lahey, W. and M. Connor. 1983. The case for ocean waste disposal. Technology Review 86(6): 60-68. (Reprinted in Currents 259:3-13).

Connor, M.S. 1984. At sea incineration: Up in smoke? Oceanus 27(1):70-74. (Reprinted in Stoldt-Nielsen newsletter).

Aubrey, D.G. and M.S. Connor. 1993. Boston Harbor: Fallout Over the Outfall. Oceanus 36(1): 61-70.

Connor, M.S. and M. Reich. 1982. Wrong ways to clean harbor. Boston Globe September 23, 1982:15.

Connor, M.S. 1987. Developing a technical program to support estuarine management: A comparison of three northeastern estuaries. Pp. 503-511 *In:* Estuarine and Coastal Management—Tools of the Trade. Proceedings of the 10th National Conference of the Coastal Society. Coastal Society: New Orleans, LA.

Connor, M.S. and R.W. Howarth. 1977. Potential effects of oil production on Georges Bank communities: A review of the Draft Environmental Impact Statement for Outer Continental Shelf oil and gas lease sale No. 42. Woods Hole Oceanographic Institution Technical Publication 77-1, 41 pp.

Kildow, J.T., D.J. Basta, R.K. Bastian, D. Brown, M.S. Connor, A.M. Freeman, III, P.M. Fye, E.D. Goldberg, P.S. Jessup, K.S. Kamlet, R.G. Kaspar, T.M. Leschine, J.S. Mattson, W.R. Muir, J.P. Murray, T. O'Connor, A. Robertson, W. Robertson, E.D. Schneider, D.A. Segar. 1984. Report of the panel on sludge management and public policy. Pp. 9-38 *In:* Disposal of Industrial and Domestic Wastes: Land and Sea Alternatives. National Academy Press, Washington, D.C.

Connor, M.S. 1983. Multi-media mayhem. Coastal Ocean Pollution Assessment News 3(1):13-14.

Connor, M.S. 1982. Is statistical significance useful in dredged material testing? Coastal Ocean Pollution Assessment News 2(2):21-23.

Connor, M.S. and W. Wiltse. 1985. Environmental management concerns in three New England estuaries. Estuaries 8(2B): 48A (abstract).

Rex, A.C. and M.S. Connor. 1997. The State of the Harbor, 1996: Questions and Answers About the New Outfall. MWRA: Boston, MA, 28 pp. (reprinted in Japanese by Japan Sewage Works Association)

Pawlowski, C., Keay, K., Graham, E.,Taylor, D.I., Rex, A.C., and M.S. Connor. 1996. The State of Boston Harbor, 1995: The New Treatment Plant Makes Its Mark. MWRA: Boston, MA, 22 pp.

Leo, W.S., Rex, A.C., Carroll S. R., and M.S. Connor. 1995. The State of Boston Harbor, 1994: Connecting the Harbor to its Watersheds. MWRA: Boston, MA, 36 pp. (reprinted in Japanese by Japan Sewage Works Association)

Connor, M.S., Coughlin, K. Lavery, P., and M. Steinhauer. 1994. The State of Boston Harbor: 1993. MWRA: Boston, MA, 21 pp.

Alber, M., Hallam, J. and M.S. Connor. 1993. The State of Boston Harbor: 1992. MWRA: Boston, MA, 52 pp.

Rex, A.C., Keay, K.E., Smith, W.M., Cura, J.J., Menzie, C.A., Steinhauer, M.S., and M.S. Connor. 1992. The State of Boston Harbor: 1991. MWRA: Boston, MA, 106 pp.

Connor, M.S. 1991. The State of Boston Harbor: 1990. MWRA: Boston, MA, 83 pp.

Environmental Engineering

Fleece, D., Brody, S. and M.S. Connor. 1992. Giardiasis and town water supplies: An analysis of disease incidence rates. Journal of New England Waterworks Assn. 106(3): 186-197.

Levin, R. , Weintraub, J., Schwartz, J., Estes-Smargiassi, and Connor, M.S. In prep. Residual disinfectant levels and gastrointestinal illness in the metropolitan Boston area. JAWWA

Connor, M.S., Rex, A.C., and M. Hornbrook. 1997. The disinfection dilemma: In search of a balance. Wet Weather Rx 2(1):14-15.

M.Connor, M.S. in press. Watershed management in Japan. Japan Society of New York: New York, NY, 12 pp.

Connor, M.S. in press. Watershed management in the United States. Japan Sewage Works Association: Tokyo, Japan, 10 pp. (in Japanese)

Connor, M.S. 1997. Comparing water and wastewater treatment in Boston and Tokyo. TMG News, Tokyo Japan. (in Japanese)

Connor, M.S. 1996. The Boston Harbor Project and the Recovery of Boston Harbor. Pp. 31-45 *In:* Clean Sea '96 in Toyohashi: International Workshop and Symposium on the Environmental Restoration of Enclosed Seas. Toyohashi, Japan. (in Japanese)

Connor, M.S. 1995. Linking Environmental Benefits to Sewerage Facilities Development: Involving the Public in Planning for Metropolitan Boston Water Quality. *In:* Proceedings of the 8th Water Environment Federation/Japan Sewage Works Association Joint Technical Seminar on Sewage Treatment Technology, Tokyo, Japan. Pp. 251-266.

Connor, M.S., Delaney, M., Ettele, N., McManus, K., and L.S. Ventry. 1993. Treatment plant identifies mystery gas. Water Environment and Technology 5(11): 13-14.

Appendix A-2

Aimee A. Keller

Address: Graduate School of Oceanography
URI Bay Campus
South Ferry Rd.
Narragansett, RI 02882

Educational History

1986 Ph.D. – Oceanography (Fisheries Biology)
University of Rhode Island
Narragansett, RI 02882

1976 M.S. – Zoology (Ichthyology)
University of Rhode Island
Kingston, RI 02881

1972 B.A. – Biology
University of Rhode Island
Kingston, RI 02881

Professional History

2001-2002 Fisheries Biologist
Port Gamble S'Klallam Tribe
Kingston, WA 98346

Duties and Accomplishments: For the past 2 years I have been a fisheries biologist/manager working for a Northwest Indian Tribe doing research on juvenile and adult salmon including Puget Sound Chinook and Hood Canal summer chum, two listed species, and forage fish (herring, sand lance and surf smelt). I have undertaken a series of projects designed to elucidate the abundance, timing and habitat use of salmon in the Hood Canal area. I have undertaken spawning surveys in North Hood Canal streams, worked on a rotary screw trap in the Hamma Hamma River, conducted snorkle surveys in West Hood Canal rivers and streams, initiated a series of studies on estuarine habitat use by juvenile salmonids, collected samples for DNA and otolith analyses, conducted stream surveys and participated in numerous pre- and post season management forums. The projects are designed to complement ongoing salmon recovery efforts in Hood Canal to benefit at risk stocks and safeguard the Tribe's cultural, ceremonial, and economic interest in healthy and resilient salmon populations. The project portfolio includes monitoring, assessment, restoration, and supplementation activities. Currently, there is a profusion of money being spent on restoration with little attention to monitoring and evaluation of management actions. The projects emphasize monitoring and assessment since without evaluation of population response to management actions (e.g.

supplementation, habitat restoration), we cannot improve our management and foster effective recovery.

1999-2001 Marine Research Scientist, Associate
Graduate School of Oceanography, URI
Narragansett, RI 02882

Duties and Accomplishments: Independent oceanographic research with salary support covered entirely by sponsored research. Write and administer grants, work with and support graduate students and technicians, present papers at meetings, publish in recognized journals, give seminars, serve on committees, work with faculty (see publications and research interests below).

A person in this classification performs basic or applied research on problems which present critical or difficult obstacles to understanding and which involve the development of new theories or methodologies with responsibility for major aspects of research projects. To achieve this classification an individual must have demonstrated the capability to obtain the funding necessary to carry on their independent research. This work will be evidenced by publications, seminars, presentations, inventions and the like, which have had national impact and value in the appropriate field or discipline.

1994-1999 Marine Research Scientist, Assistant
Graduate School of Oceanography, URI
Narragansett, RI 02882

Duties and Accomplishments: This position requires post-doctoral research experience with research funds provided through sponsored research. Initially, the duties include working on research projects funded by faculty or higher level marine research scientists. With advancement, the duties include becoming CO-PI or PI on sponsored research. Responsibilities include identification and selection of the problems to be studied and organization and presentation of results.

1990-2000 Adjunct Faculty
Roger Williams University
One Old Ferry Road
Bristol, RI 02809

Duties and Accomplishments: Teach courses in Ichthyology, Oceanography, Introductory Biology, Invertebrate Biology, Marine Zoology, Marine Ecology and Science Writing at the undergraduate levels, introduce upper level students to independent research, serve as research adviser for senior thesis, provide guidance and letters of recommendation for graduate study. My accomplishments include seeing many of my students move on to graduate school, teaching awards, exchange of ideas and lasting friendships.

1988-2001 Consultant
Applied Science Associates Inc.
Dean Knauss Rd.
Narragansett, RI 02882

Duties and Accomplishments: My duties as a consultant have typically included providing expertise as needed in the field of ichthyology, larval and juvenile fish habitat studies, fisheries biology, modeling and data analysis of fishery related projects and providing guidance on proposal writing in fishery related areas. Accomplishments included publication of research in recognized journals, presentations at national meetings and report preparation. I am also conducting a ten-year monitoring program of the fishes of the Blackstone River, RI – using electrofishing and seining techniques.

1988-1994 Marine Scientist, Assistant
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882

Duties and Accomplishments: This was an entry level research position in which funding was provided initially through the sponsored research of the faculty. My duties were to perform basic or applied research in an area of complexity in which theory or methods may be limited or lacking. A faculty member guides a person in this position. Accomplishments included acceptance of publications and presentations at national meetings.

1986-1988 Marine Research Associate
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI

Duties and Accomplishments: This was an entry level research position in which funding was provided through the sponsored research of the faculty. My duties were to conducted long-term analyses of finfish databases for Narragansett Bay area and publish results in reports and journals.

1980-1988 Programmer
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882

Duties and Accomplishments: Maintain data base for the Marine Ecosystems Research Laboratory using SAS; provide data analyses and statistical advice for faculty and staff at MERL, attend classes, undertake research for Ph.D., publish data reports.

1977-1980 Marine Research Specialist
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882

Duties and Accomplishments: Participant in nutrient addition experiment in the MERL mesocosms, collect and analyze data, write reports, provide illustrations for publications

1976-1977 Marine Research Biologist
Seattle Aquarium, Seattle, WA

Duties and Accomplishments: Participant in designing, collecting and setting up fish exhibits for aquarium

1976 Fishery Biologist
NOAA, National Marine Fisheries Service
Northwest Fisheries Center
Resource Ecology and Fisheries Management
Seattle, WA

Duties and Accomplishments: Perform research in the biology and life cycles of marine fish species particularly those inhabiting the North Pacific Ocean and Bering Sea, with emphasis on early life stages. This research may include (a) examination of historical reports in the U.S., Japanese, and Soviet literature concerning the abundance and distribution of ichthyoplankton, (b) identification of ichthyoplankton collected by the project or by other groups. (c) monitoring changes in abundance and distribution of ichthyoplankton, especially that of the Bering Sea; (d) providing various inputs to ecosystem models. Duties also include identification of ichthyoplankton at various stages of life, making counts, measurements and other observations of ichthyoplankton and juvenile fish, prepare graphic and tabular summaries, and prepare laboratory results for data processing.

1975-1976 Research Assistantship
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882

Duties and Accomplishments: Participate in studies of alewife populations in Rhode Island coastal waters. Provide assistance in field sampling, data acquisition, and report preparation.

1974-1975 Fishery Biologist
National Museum of Natural History
Smithsonian Institution
Washington, D.C. 20560

Duties and Accomplishments: Participate in identification, sexing and staging mid-water and deep sea fish from the deep water dumpsite off New York, analyze data, prepare reports and assist in writing publications

1972-1974 Teaching Assistantship
Department of Zoology
University of Rhode Island
Kingston, RI 02881

Duties and Accomplishments: Teach laboratory sessions for introductory biology, anatomy and embryology and oceanic ichthyology

1972 Research Assistant
Graduate School of Oceanography
University of Rhode Island

Duties and Accomplishments: Participate in studies of striped bass populations in Rhode Island coastal waters. Provide assistance in field sampling, data acquisition, and report preparation

Honors, Awards, Special Skills

1. Honors and Awards
Roger Williams University - Teacher of the Year 1999
Roger Williams University - President's Evening of Excellence Award 1999
Senior Research Fellowship, Global Change Research - National Academy of Science 1996-97
Graduate Research Assistantship 1974-76
Graduate Teaching Assistantship 1972-74
Summa Cum Laude 1972

2. Special Skills
SAS-expertise in application of SAS (Statistical Analysis Systems)
Model Development and Implementation
Fish Population Dynamics
Mesocosm Experiments in Large Scale (13,000 L) Systems
GIS - Geographic Information Systems (ArcInfo and ArcView)
Habitat Analysis
Ecosystem Modeling
Salmonid Research
Ichthyoplankton Identification
Zooplankton Identification
Phytoplankton Identification

Research Activities:

A. Area of Specialization

I have a strong background in oceanography with emphasis on ichthyology and fisheries biology. I have extensive training in salmon biology, ichthyoplankton, fish population dynamics, trophic ecology and phytoplankton production modeling. My research interests include various aspects of marine ecology including the study of eutrophication, estuarine and coastal ecology, mesopelagic and deep-sea fish taxonomy, and ecosystem analysis. I have a broad background in modeling, univariate statistical analyses, multivariate analyses and geographic information systems (GIS, ArcView and ArcInfo). I am particularly interested in the habitat requirements of juvenile fish and the trophic links between primary productivity and higher trophic levels. Most recently I have specialized in the impact of global climate change on phytoplankton bloom dynamics and possible impacts of the changing climate on the trophic structure leading to fish. As indicated in my publications I also have experience in modeling population dynamics. I have worked with graduate students and undergraduates on many of my sponsored research projects. I have an extensive background in the analysis of complex datasets and modeling. I enjoy writing manuscripts for publication and giving seminars. I maintained an adjunct faculty position for many years in addition to my research activities because of my desire to communicate with students.

B. Research programs where I have been principal, or co-principal investigator

2002	Pacific coastal salmon recovery projects in North Hood Canal, NOAA ($417,500) with Ted Labbe
2002	Pacific salmon treaty implementation funds, BIA ($95,937)
2002	Improvement of salmon spawning facility at the Little Boston Hatchery, Hatchery Reform Proposal, NWIFC ($26,000)
2001	Pacific coastal salmon recovery projects in North Hood Canal, NOAA ($285,000) with Ted Labbe
2001	Pacific salmon treaty implementation funds, BIA ($90,807)
2000-2002	Monitoring of ichthyoplankton abundance in Narragansett Bay and Rhode Island territorial waters, RI Department of Environmental Management Grant ($60,000) with Grace Klein-MacPhee
1998-2006	Water Quality Monitoring in Massachusetts Bay, Battelle Environmental Laboratory, MA Water Resource Authority Grant ($588,000/yr) with C. A. Oviatt

1998-1999	Evaluation of the Water Quality Analysis Simulation Program Version 5 (WASP) Model Using Mesocosm Data, US EPA Grant ($53,000/yr)
1997-1998	Commercial culture of Tautog (blackfish): Meeting market preferences and needs, RI Ocean Technology Development Grant ($46,265/yr) with Grace Klein-MacPhee
1997	Effects of nutrient loading and warming on the structure and function of coastal ecosystems, National Academy of Sciences Senior Research Fellowship ($47,333/yr)
1996-1997	Potential effects of North Cape Oil Spill on the zooplankton, fish, shellfish, and benthos of Cards Pond, RI, Audubon Society Grant ($10,000)
1995	Compilation of Ecological Risk Assessment data for Narragansett Bay, San Diego University Foundation ($29,998)
1994	Development of a plan for inventory and monitoring of submerged aquatic resources (shellfish and fish) at Cape Cod National Seashore, National Park Service Grant ($50,000)
1993-1994	Effects of Ultraviolet-B Radiation on Marine Trophic Levels, US EPA Grant ($199,834/yr)
1992	NOAA Database Document NOAA/NMFS Grant, Narragansett Laboratory ($11,027)
1991 - 1992	Review of Hypoxic Effects: New York New Jersey Harbor Estuary, US EPA Grant ($50,000)
1990 - 1993	Water Quality and ecological evaluation of Bass Harbor Marsh (Acadia National Park Maine) National Park Service Grant ($159,362/yr.)
1989 - 1990	Nutrients and Organic Enrichment in the New York-New Jersey Harbor Estuary, US EPA Grant ($130,000)
1989 -1990	Habitat Inventory/Resource Mapping for Narragansett Bay and Associated Bay Coastline, Shellfish and Finfish Section, Narragansett Bay Project Grant

C. Papers presented/posters from professional meetings:

Keller, A.A. 1999. Phytoplankton production: long-term trends and the 1998 bloom failure, Annual MWRA Monitoring Meeting, Duxbury, MA, June 1999.

Keller, A.A., C.A. Oviatt, T. Dorrington, G. Holcombe and L. Reed. 1999. Long-term trends in productivity in Massachusetts Bay, (Poster) Boston, MA, Oct. 1999.

Klein-MacPhee, G. and A. Keller. 1999. Early induction of spawning of a captive tautog broodstock by light and photoperiod manipulation. 19th Milford Aquaculture Seminar, Milford CT. Feb 27-Mar. 1.

Yankocy, S., G. Klein-MacPhee and A. Keller. 1999. Feeding studies on juvenile tautog, two experiments: Weaning juvenile tautog to an artificial diet and effects of feeding frequency on growth of juvenile tautog. 19th Milford Aquaculture Seminar, Milford CT. Feb 27-Mar. 1.

Klein-MacPhee, G., R. Lovett, A. Keller and B. Walker. 1998. Raising tautog to assess their potential for aquaculture- triumphs and heartaches. (Poster)18th Milford Aquaculture Seminar, New Haven CT. Feb 23-25.

Keller, A.A. 1998. Phytoplankton production modeling, Annual MWRA Monitoring Meeting, Duxbury, MA, March 1998.

Keller, A.A., P. Hargraves, H. Jeon, G. Klein-MacPhee, C. Oviatt and J. Zhang. 1997. Impact of enhanced UV-B radiation on the marine ecosystem in stratified coastal waters. Abstract ASLO Feb. 1997 Sante Fe, NM

Keller, A.A. 1997. Effects of warming and nutrient enrichment on marine trophic levels in coastal systems. Invited Speaker, EPA Narragansett Seminar Series, May 1997.

Keller, A.A. 1997. Effects of warming on the structure and function of nutrient rich coastal systems, ERF, Providence RI, Oct. 12-15, 1997.

Klein-MacPhee, G, A.A. Keller and H. Rines. 1996. The fish biota of the Blackstone River, Woonsocket, Rhode Island. Rhode Island Natural History Society Annual Meeting, Bristol RI Jan 19 1996 (Poster)

Keller, A.A., P. Hargraves, H. Jeon, G. Klein-MacPhee, C. Oviatt and J. Zhang. 1996. The effects of UV-B enhancement on the marine trophic levels in stratified coastal ecosystems. New England Estuarine Research Society Meeting, 24-26 Oct. 1996 Block Island, RI

Klein-MacPhee, G, A.A. Keller, H. Jeon, E. Klos and C. Oviatt. 1995. The effects of ultraviolet-B radiation on bay anchovy, *Anchoa mitchilli*, in a model ecosystem. 19th Annual Larval Fish Conference, AFS Early Life History Section Meeting, Sydney, Australia. June 26-July 2 1995.

Frithsen, J., S.Weisberg, C. Oviatt and A. Keller. 1995. An index of eutrophication for polyhaline waters. Estuarine research Federation, 13th Biennial International Conference. Nov. 12-16, 1995, Texas

Keller, A.A., P. Hargraves, H. Jeon, G. Klein-MacPhee, C. Oviatt and J. Zhang. 1994. Spring 1994 New England Estuarine Research Society Meeting, Salem MA, June 2-4, 1994. The effects of ultraviolet-B radiation on marine trophic levels during a winter-spring bloom.

Klein-MacPhee, G, A.A. Keller, C. Oviatt and E. Klos. 1994. 18th Annual Larval Fish Conference, AFS Early Life History Section Meeting, St. Andrews, New Brunswick. June 16-24, 1994. Effects of ultraviolet-B on fish embryos.

Berounsky, V.M., K.R. Hinga, V. Lee, S.W. Nixon, M.E.Q. Pilson, A Desbonnet, A. Keller, B. Kopp, and D.W. Stanley. 1994. Examining estuarine eutrophication: The role of Vollenweider, chlorophyll, nitrogen and tidal range. New England Estuarine Research Society Meeting, June, 1994 Salem, MA.

Keller, A.A. 1993. Finfish inventory and monitoring in the Cape Cod National Seashore. National Seashore Workshop, National Park Services, Cape Cod. February 23-25, 1993.

Berounsky, V.M., K.R. Hinga, V. Lee, S.W. Nixon, M.E.Q. Pilson, A. Desbonnet, A. Keller, B. Kopp, and D.W. Stanley. 1993. Identifying effects of estuarine eutrophication: analyses of existing data on selected estuaries. Twelfth Biennial International Estuarine Research Federation Conference. November 1993, Hilton Head, SC.

Klein-MacPhee, G., A.A. Keller, and J. St.Onge Burns. 1992. Changes in abundance and distribution of ichthyoplankton in Narragansett Bay, Rhode Island, USA: A response to changes in environmental quality? ECSA/ERF Conference - Plymouth, U.K. September 14-17, 1992.

Sullivan, B.K., P. Doering, C.A. Oviatt, J. Frithsen and A. Keller. 1991. Experimental studies reveal benthic control of pelagic food webs. Meeting of the American Society of Limnology and Oceanography, Halifax, Nova Scotia, June 10-14 1991. Invited.

Hinga, K. and A.A. Keller. 1990. Oxygen concentrations in the New York-New Jersey Harbor: comparisons between data sets. New York-New Jersey Harbor program, Federal Building, New York City, July 10 1990.

Keller, A.A. 1990. Long term trends in oxygen concentrations: New York-New Jersey Harbor Estuary; Hudson River Foundation Annual Meeting, Museum of Natural History, New York City, December 1990.

Keller, A.A. and K. Hinga. 1990. New York-New Jersey Harbor Estuary Program: Nutrients and organic enrichment. New-York-New Jersey Harbor estuary program scientific and technical advisory committee meeting. New York City, NY. May 1990.

Klein-MacPhee, G., B. Sullivan and A.A. Keller. 1990. Growth and survival of winter flounder larvae in mesocosms. 14th Larval Fish conf., Amer. Fish Soc., Beaufort, NC. May 6-9 1990.

Jaworski, N.J. and A.A. Keller. 1989. Nitrogen sources in the upper Potamac River basin. Int. Est. Res. Conf. Oct 8-12, Baltimore, MD.

Keller, A.A. 1989. Atmospheric deposition to coastal estuaries. EPA/MERL Workshop on Eutrophication of coastal waters by Atmospheric Deposition on Watersheds. Narragansett, RI, March 6-17, 1989.

Rose, K.A., L.W. Barnthouse, G.K. MacPhee, B. Sullivan, A.A. Keller, D. Danila and D. Miller. 1989. Winter flounder young-of-the-year growth and survival in mesocosm and field ecosystems. Amer. Fish. Soc. Annual Meeting (Alaska).

Doering, P.H., A.A. Keller, B.K. Sullivan and S. Kelly. 1987. Comparative growth of Atlantic menhaden, *Brevoortia tyrannus* (Pisces: Clupeidae) in MERL mesocosms: Effects of eutrophication. ASLO, New Orleans, LA.

Keller, A.A., P. Jeffries and S. Hale. 1987. Time series analysis of Narragansett Bay's winter flounder population. Narragansett Bay Project Annual Meeting, EPA, Narragansett, RI.

D. Additional Meetings Attended

1996-Winter flounder workshop, Mystic Conn.
1997-Atlantic States Marine Fisheries Commission, Atlantic City, N.J.
1997-U.S. GLOBEC meeting for Georges Bank, Cape Cod, Mass.

E. Lectures, and special seminars, other than at professional meetings:

1999 Seminar, Impact of elevated temperature on growth and survival of winter flounder, Friends of Oceanography, Science Series, Narragansett, RI

1999 Seminar, Impact of nutrient loading on dissolved oxygen concentration: a mesocosm analysis, Seminar Series, RI DEM, Prov. RI

1998 Seminar, Effects of warming on the structure and function of coastal marine systems, Seminar Series, Roger Williams University, Bristol, RI

1997 Seminar, Impact of elevated temperature on the magnitude of the winter-spring phytoplankton bloom: consequences of global warming, GSO Narragansett, RI

1997 Seminar, Impacts of nutrient loading and warming on coastal marine systems, US EPA Narragansett, RI

1996 Seminar, Culturing winter flounder for restoration: a feasibility study, Roger Williams University, Bristol, RI

1993 Guest Lecture for Marine Zoology, Roger Williams University, Bristol, RI

1990 Two guest lectures for General Biology, Roger Williams University, Bristol, RI

1990 Two guest lectures for Science Writing, Roger Williams University, Bristol, RI

1990 Seminar , Ichthyoplankton Research in Narragansett Bay and the MERL Mesocosms, Departmental Science - Mathematics Seminar Series, Roger Williams University, Bristol, RI

F. Offices held in, and services rendered to, professional societies and memberships in professional and honor societies:

1. American Association for the Advancement of Science
2. American Society of Limnology and Oceanography
3. Summa Cum Laude - Graduated; invited to join National Honor Society (Alpha Chi)
4. New England Estuarine Research Society

G. Special services rendered such as journal editor, agency research review board:

1. Manuscript Reviews, Marine Ecology Progress Series
2. Proposal Reviews, Hudson River Foundation,
3 Proposal Reviews, National Science Foundation
4. Proposal Reviews, NOAA
5. Material Review, NOAA, National Estuarine Inventory Project
6. Manuscript Reviews, Estuaries
7. Manuscript Reviews, J. of Marine Biological Association of the United Kingdom
8. Manuscript Reviews, Limnology and Oceanography

Bibliography

Key:
J=Articles in Professional Journals
A=Abstracts of Conference Presentations
C=Papers in Conference Proceedings
B=Books and Book Sections
P=Popular Articles
R=Reports
O=Other
T=Thesis

J Doty, T.L, C.R. Shoop and A.A. Keller. 2002. Long-term success of a Rhode Island amphibian community. Science (in prep.).

J Oviatt, C.A., A.A. Keller and L. Reed. 2002. Production in Narragansett Bay with no bay-wide winter-spring phytoplankton bloom. Estuarine, Coastal and Shelf Science. 54:1013-1026.

J Keller, A.A., C. Taylor, C. Oviatt, T. Dorrington, G. Holcombe and L. Reed. 2001. Phytoplankton production patterns in Massachusetts Bay and the absence of the 1998 winter- spring bloom. Marine Biology 138:1051-1062

J Keller, A.A. and G. Klein-MacPhee. 2000. Impact of elevated temperature on growth, survival, and trophic dynamics of winter flounder larvae: A mesocosm study. Can. J. Fish. Aquat. Sci. Can. J. Fish. Aquat. Sci. 57:2382-2392.

J Keller, A.A., G. Klein-MacPhee and J. St. Onge-Burns. 1999. Abundance and distribution of ichthyoplankton in Narragansett Bay, Rhode Island, 1989-1990. Estuaries 22:149-163.

J Keller, A.A., C.A. Oviatt, H.A. Walker and J.D. Hawk. 1999. Predicted impact of elevated temperature on the magnitude of the winter-spring phytoplankton bloom in temperate coastal waters: A mesocosm study. Limno. Oceanogr. 44:344-356.

A Yankocy, S., G. Klein-MacPhee and A. Keller. 1999. Feeding studies on juvenile tautog, two experiments: Weaning juvenile tautog to an artificial diet and effects of feeding frequency on growth of juvenile tautog. 19th Milford Aquaculture Seminar, Milford CT. Feb 27-Mar. 1.

R Keller, A. A. and C.A. Oviatt. 1999. Impact of nutrient loading on dissolved oxygen concentration: a mesocosm analysis. US EPA, Boston

B Keller, A.A., C.A. Oviatt and E. Klos. 1999. Mesocosms:applications to phytoplankton ecology and production, In: Durvasula, S.V. (ed.) Pelagic Ecology Methods (in press).

A Klein-MacPhee, G. and A.A. Keller. 1999. Early induction of spawning of a captive tautog broodstock by light and photoperiod manipulation. J. Shellfish Res. 18:259-280

J Frithsen, J., S.Weisberg, A.A. Keller and C. Oviatt. 1999. A simple eutrophication index for shallow estuarine and coastal waters. Estuaries (accepted).

A Klein-MacPhee, G., R. Lovett, A.A. Keller and B. Walker. 1998. Raising tautog to assess their potential for aquaculture- triumphs and heartaches. 18th Milford Aquaculture Seminar, Feb 23-25, 1998 New Haven CT.

R Klein-MacPhee, G. and A.A. Keller. 1998. Final report of 1998 finfish monitoring in the Blackstone River. Ocean State Power, Harrisville, RI.

R Klein-MacPhee, G. and A.A. Keller. 1998. Final report of 1997 finfish monitoring in the Blackstone River. Ocean State Power, Harrisville, RI.

R Libby, S., L. McLeod, C. Albro, C. Hunt, A. Keller, C. Oviatt, J. Turner. 1998. Semi-annual water column monitoring report February - July 1998. Massachusetts Water Resource Authority, Boston

J Keller, A.A., P. Hargraves, H. Jeon, G. Klein-MacPhee, E. Klos, C. Oviatt and J. Zhang. 1997. The effects of ultraviolet-B radiation on marine trophic levels in stratified coastal systems. Mar. Biol. 130:277-287.

J Keller, A.A., P. Hargraves, H. Jeon, G. Klein-MacPhee, E. Klos, C. Oviatt and J. Zhang. 1997. The effects of ultraviolet-B radiation on marine trophic levels during a winter-spring bloom. Ecoscience 4:129-139.

R Klein-MacPhee, G. and A. Keller. 1997. Final report of 1996 finfish monitoring in the Blackstone River. Ocean State Power, Harrisville, RI.

A Keller, A.A. 1997. Effects of warming on the structure and function of nutrient rich coastal systems, ERF, Providence RI, Oct. 12-15, 1997.

R Klein-MacPhee, G. and A.A. Keller. 1996. Final report of 1995 finfish monitoring in the Blackstone River. Ocean State Power, Harrisville, RI.

R Latimer, J., A.A. Keller, C. Oviatt, and H. Walker. 1996. Diagnostic techniques for phytoplankton productivity assessments: A comparison of active fluorometry to conventional approaches. Strategic Environmental Research and Development Program, US EPA

R Keller, A.A., M.E.Q. Pilson, and R.K. Johnston. 1996. Estuarine Profile of Narragansett Bay, Rhode Island. San Diego University Foundation

R Beatty, L.L., B. Nowicki, A.A. Keller, R.A. Wahle, C. LaBash, P.V. August. 1995. A plan for inventory and monitoring of estuarine resources at Cape Cod National Seashore. Final report to the National Park Service, Wellfleet, MA. 280 pp.

R Keller, A. and G. Klein-MacPhee. 1995. Final report of 1994 finfish monitoring in the Blackstone River. Ocean State Power, Harrisville, RI.

A Frithsen, J., S.Weisberg, C. Oviatt and A. Keller. 1995. An index of eutrophication for polyhaline waters. Estuarine research Federation, 13th Biennial International Conference. Nov. 12-16, 1995

O Jossi, J., J. Goulet, R. Benway, A.A. Keller and S. Smith. 1994. MARMAP Ecosystems Manual; at sea data collection. NOAA Tech. Mem. 111 p.

R Doering, P.H., C.T. Roman, L.L. Beatty, A.A. Keller, C.A. Oviatt, B.D. Zubricki and L.W. Reed. 1994. Water Quality and Habitat Evaluation of Bass Harbor Marsh, Acadia National Park, Maine. Final Report Submitted to: NPS Office of Scientific Studies, Boston, MA

B Klein-MacPhee, G., B.K. Sullivan, and A.A. Keller. 1993. Using mesocosm to assess the influence of food resources and toxic material on larval fish growth and survival. AFS Symposium Series 14:105-116.

R Doering, P.H., C.T. Roman, L.L. Beatty, A.A. Keller, C.A. Oviatt, B.D. Zubricki and L.W. Reed. 1992. Water Quality and Habitat Evaluation of the Bass Harbor Marsh Estuary (Acadia National Park). Progress Report Submitted to: NPS Water Resources Div., Fort Collins, Co.

J Jaworski, N.J., P. Groffman, A. Keller and J. Prager. 1992. A watershed-scale analysis of nitrogen loading: The upper Potamac River. Estuaries. 15:83-95.

R Keller, A.A. and G. Klein-MacPhee. 1992. Finfish in Habitat Inventory/Resource Mapping for Narragansett Bay and Associated Coast Line. D. French and H. Rines eds. Final Report to the Narragansett Bay Project, Applied Science Associates In. 89-33. June 7, 1992.

J Sullivan, B.K., P.H. Doering, C.A. Oviatt, A.A. Keller and J.B. Frithsen. 1991. Interactions with the benthos alter pelagic food web structure in coastal waters Can. J. Fish. Aquat. Sci. 48:2276-2284.

J Hinga, K.R., A.A. Keller and C.A. Oviatt. 1990. Atmospheric Deposition and Nitrogen Inputs to Coastal Waters. Ambio 6:256-260.

R Keller, A.A. 1990. Fisheries data base for oil spill impact model for purpose of contingency planning in the Gulf of Alaska. Report to Applied Science Associates, Narragansett, RI.

R Keller, A.A. 1990. Biological data base for Natural Resource Assessment model for Great Lakes Environment (NRDAM/GLE) Type A model under CERCLA. Report to Applied Science Associates, Narragansett, RI.

J Keller, A.A., L.L. Beatty, L.E. Weber, and C. Heil. 1990. Soluble DCMU-enhanced fluorescence: effects on in vivo chlorophyll a determination at different salinities. Can. J. Fish. Aquat. Sci. 47: 1700-1709.

J Keller, A.A., P.H. Doering, S. Kelly and B.K. Sullivan. 1990. Comparative growth of young Atlantic menhaden, *Brevoortia tyrannus* (Pisces: Clupeidae) in MERL mesocosms: Effects of eutrophication. Limnol. Oceanogr. 35:109-122.

J Keller, A.A. and R.L. Rice. 1990. Effects of nutrient enrichment on natural populations of the brown-tide phytoplankton (*Aureococcus anophagefferens*). Jour. of Phycology 25:636-646.

J Keller, A.A. and R.L. Rice. 1990. Variation in DCMU-enhanced fluorescence relative to chlorophyll a: correlation with the brown tide bloom. Jour. of Phycology 26:202-205.

R Saila, S.B. and A.A. Keller. 1990. Suggestions regarding management planning for some vertebrate and invertebrate resources of Narragansett Bay. Report. New England Interstate Water Pollution Commission and the Narragansett Bay Project

R Doering, P.H., A.A. Keller and C.A. Oviatt. 1989. Eutrophication of coastal waters - roles of silicon and the benthos: A mesocosm experiment data report. MERL series report No. 8. The University of Rhode Island, Kingston, RI.

R Hinga, K.R., N. Lewis, R. Rice, K. Dadey and A. Keller. 1989. A Review of Narragansett Bay Phytoplankton Data: Status and Trends. New England Interstate Water Pollution Commission and the Narragansett Bay Project.

J Jeffries, H.P., A.A. Keller and S. Hale. 1989. Predicting winter flounder (*Pseudopleuronectes americanus)* catches by time series analysis. Can. J. Fish. Aquat. Sci. 46:650-659.

J Keller, A. A. 1989. Modeling the effect of temperature, light and nutrients on primary productivity: a comparison of two approaches, mechanistic versus empirical. Limnol. Oceanogr. 34: 82-95.

J Keller, A. A. and U. Riebesell. 1989. Phytoplankton carbon dynamics during a winter-spring diatom bloom in an enclosed marine ecosystem: primary production, biomass and loss rates. Mar. Biol. 103:131-142.

A Doering, P.H., A.A. Keller, B.K. Sullivan and S. Kelly. 1988. Comparative growth of Atlantic menhaden, *Brevoortia tyrannus* (Pices: Clupeidae) in MERL mesocosms: Effects of eutrophication. EOS 68:1724.

R Jeffries, H.P., S. Hale and A.A. Keller. 1988. Historical data assessment-finfishes of the Narragansett Bay area. Report 1988. Narragansett Bay Project, University of Rhode Island, Kingston, RI.

J Keller, A.A. 1988. Modeling primary productivity (^{14}C) using mesocosms data along a nutrient gradient. J. Plankt. Res. 10: 813-834.

J Keller, A.A. 1988. Estimating phytoplankton productivity from light availability and biomass in the MERL mesocosms and Narragansett Bay. Mar. Ecol. Prog. Ser. 45: 159-168.

R Frithsen, J.B., C.A. Oviatt and A.A. Keller. 1987. A comparison of ecosystem and single-species tests of sewage effluent toxicity: a mesocosm experiment data report. MERL Series Report No. 7, The University of Rhode Island, Kingston, RI.

R Jeffries, H.P., S. Hale and A.A. Keller. 1987. Commercial fisheries catch in Narragansett Bay and the adjacent offshore area: summarization of National Marine Fisheries Service data on commercial fisheries landings. 1964-1968. Report 1987-2. Narragansett Bay Project, The University of Rhode Island, Kingston, RI.

R Jeffries, H.P., A.A. Keller and S. Hale. 1987. Finfishes of the offings to the Narragansett Bay Area, RI: Summarization of National Marine Fisheries Service Groundfish Surveys 1963-1986. Report 1987-1. Narragansett Bay Project, The University of Rhode Island, Kingston, RI.

J Keller, A.A. 1987. Mesocosm studies of DCMU-enhanced fluorescence as a measure of phytoplankton photosynthesis. Mar. Biol. 96: 107-114.

J Keller, A.A. 1987. Modeling and forecasting primary production rates using Box-Jenkins transfer function models. Can. J. Fish. Aquat. Sci. 44: 1045-1052.

R Jeffries, P., S. Hale and A.A. Keller. 1986. Finfish compilation for Mount Hope Bay and the Providence River, Rhode Island: Otter trawls and power plant intake screens. Report 1986-2. Narragansett Bay Project, The University of Rhode Island, Kingston, RI.

R Jeffries, P., A.A. Keller and S. Hale. 1986. Catch compilation: Weekly Trawl Program Narragansett Bay-Rhode Island Sound 1966-1985. Report 1986-1. Narragansett Bay Project, The University of Rhode Island, Kingston, RI.

T Keller, A.A. 1986. Modeling the productivity of natural phytoplankton populations using mesocosm data along a nutrient gradient. PhD Thesis, University of Rhode Island, Kingston, RI, 240 pp.

J Oviatt, C.A., A.A. Keller, P.A. Sampou, and L.L. Beatty. 1986. Patterns of productivity during eutrophication: A mesocosm experiment. Mar. Ecol. Prog. Ser. 28: 69-80.

J Oviatt, C.A., D.T. Rudnick, A.A. Keller, P.A. Sampou, and G.T. Almquist. 1986. A comparison of system (O_2 and CO_2) and C-14 measurements of metabolism in estuarine mesocosms. Mar. Ecol. Prog. Ser. 28: 57-67.

R Frithsen, J.B., A.A. Keller and M.E.Q. Pilson. 1985. Effects of inorganic nutrient additions in coastal areas: A mesocosm experiment data report. Volume 1. MERL Series Report No. 3, The University of Rhode Island, Kingston, RI.

R Frithsen, J.B., P.A. Lane, A.A. Keller and M.E.Q. Pilson. 1985. Effects of inorganic nutrient additions in coastal areas: A mesocosm experiment data report. Volume 2. MERL Series Report No. 4, The University of Rhode Island, Kingston, RI.

R Krueger, W.H., R.H. Gibbs, Jr., R.C. Kleckner, A.A. Keller and M.J. Keene. 1977. Distribution and abundance of mesopelagic fishes on cruises 2 and 3 at Deepwater Dumpsite 106. In: Baseline report of environmental conditions in Deepwater Dumpsite 106, NOAA Dumpsite Eval. Rep. 77-1:377-422.

T Keller, A.A. 1976. Systematics, vertical distribution and life history of Anguilliform leptocephali in the Bermuda Ocean Acre. M.S. Thesis, University of Rhode Island, Kingston, RI 256 pp.

R Krueger, W.H., M.J. Keene and A.A. Keller. 1975. Systematic analysis of midwater fishes obtained at Deepwater Dumpsite 106, NOAA Dumpsite Eval. Rep. 75-1:359-388.

<u>Appendix A-3</u>

Douglas R. Levin

EDUCATION
Ph.D. Marine Sciences/Geology, Louisiana State University, 1990
MA Geology, Boston University, 1981
B.S. Biology, Fairleigh Dickinson University, 1978

ACADEMIC AWARDS & RECOGNITION
1997: Distinguished Alumni Professor
1997 & 1998: Advisor of the Year
1996: Community Service Leadership Award (Rhode Island Campus Compact)
1994: Outstanding Teaching Award in Liberal Arts

<u>PROFESSIONAL EXPERIENCE</u>
2001- Present Director, Earth Mapping Laboratory, University of Maryland Eastern Shore
1990- 2000 Assistant/Associate Professor & Chair Science & Technology, Bryant College
1989-1990 Coastal Geologist, CERC, Vicksburg, MS
1988-1989 Project Geologist, Atlantic Environmental, Colchester, CT
1985-1988 Program Manager, Ocean Surveys, Inc., Old Saybrook, CT
1980-1982 Assistant Scientist, EG&G, Environmental Division, Waltham, Ma.

Grants Received 2001

2001 Research Participation in Airborne Oceanographic LIDAR on Long Range P-3 Missions, with Wallops Flight Facility of Goddard Space Flight Center of NASA – ($27,623/year, renewable) Grant Continuation awarded April of 2002 to determine utility of ArcView to plot Lidar data and analyze Assateague Barrier Island erosion.

2001 (with D. Krantz) Influence of Geologic Framework on Shoreline Retreat Rates, Assateague Island National Seashore, Maryland and Virginia, North Atlantic Cooperative Ecosystems Studies Unit, ($89,964 over two years (through 2004). (Graduate Student funding for 2 years).

SELECTED SCHOLARLY & PROFESSIONAL ACTIVITIES

Levin, D.R. and Montvilo (1998) Applied Coastal Oceanography: A Course That Integrates Science and Business. Journal of College Science Teaching. Volume 27, No. 5. 329-333

Levin, D.R. and J. Montvilo (1996) Shipwreck location as a tool to tie science and business disciplines. Journal of College Science Teaching. Volume 26, No. 1. 31-33.

Levin, D.R. (1995) Occupation of a relict distributary system by a new tidal inlet, Quatre Bayou Pass, Louisiana. In Flemming and Bartholma (eds) Special Publication International Association of Sedimentology. Tidal Signatures in Modern and Ancient Environments. V. 24, 71-84.

Levin, D.R. (1993) Tidal Inlet Evolution in the Mississippi River Delta Plain. Journal of Coastal Research. 9:2:462-480.

Levin, D.R. and V. Vignaly (2000) Investigated submerged villages in surface water reservoirs of
New England utilizing Seafloor Mapping Technologies, Ocean Imaging Conference 2000, Newport, Rhode Island, May 2nd to 5th, 2000.

"Technology in the classroom", Conducted training for high school teachers using computer connected data collection techniques in various laboratory settings, Moriches, NY (October, 1999).

"Riverlinks", the creation of Youth Watershed Councils, Invited Presentation for 8th annual Environmental Conference at Northbridge High School, Northbridge, Massachusetts. (April 7, 1999).

"A multimedia report on the geotechnical Investigation of Wachusett Reservoir, Massachusetts". Presented to the Metropolitan District Commission, Commonwealth of Massachusetts, as an invited professional lecture (September, 1998).

"Transoceanic Classroom". Two classes studying rivers of similar industrial histories in England and Rhode Island compared data collected through the summer of 1997 at the World Canal Conference (October 1997).

Sample Grants Received

2002 Data Sharing for Research and Education. NOAA teaching grant to link 6 Delmarva High Schools in an environmental, water quality study in the area ($300,000 over three years)

2001 Research Participation in Airborne Oceanographic LIDAR on Long Range P-3 Missions, with Wallops Flight Facility of Goddard Space Flight Center of NASA – ($27,623/year, renewable)

2001 Influence of Geologic Framework on Shoreline Retreat Rates, Assateague Island National Seashore, Maryland and Virginia, North Atlantic Cooperative Ecosystems Studies Unit, ($89,964 over two years (through 2004).

1998 & 1999 Greater Rhode Island Job Training Partnership ($41,000) for RIVERLINKS summer teaching program. This award-winning program brought twelve high school students from northern Rhode Island to Bryant College during the summers of 98 & 99 to show them that industry can co-exist with the environment without causing undue ecological and subsequent economic harm.

1997 - 1998 Eisenhower Grant recipient ($45,000), Melding Science & Technology for High School and Middle School Math and Science Teachers of Rhode Island. Sixteen teachers from Rhode Island attended Bryant College learning to use of data collection sensors connected to laptop computers.

SAMPLE OF RECENT PROFESSIONAL PROJECTS

- Side Scan Sonar Data Acquisition for the Maryland Geological Survey in the Chesapeake Bay.
- Thales GeoSolutions, 2002, Map oil and gas seeps in seafloor off of Cartagena, South America
  Institute For Exploration, 2001, Geologist exploring Noah's Flood theory for the Black Sea
- NASA/EG&G LIDAR Operator for Ice Thickness Mapping, Iceland, Greenland 2001
- Institute for Exploration, 2001, Thunder Bay Marine Sanctuary; Shipwreck Inventory
- Institute for Exploration, 2000, Site Identification of Native People Occupation in the Block
  Island near-offshore area.
- Boeing & Thales, 2000, Geologist for Fiber Optic Route selection, Aleutian Islands (4,000 km)
- Geological Assistance Services, Bologna, Italy, Assisted with the mapping and route selection of a
  transatlantic telecommunications cable, Straits of Gibraltar, Spain (summer 1998).
- Racal Geotechnical Services, Houston, Texas, Assisted with seafloor mapping and route selection for
  pipeline installation surveys in Gulf of Mexico (summer, 1997).
- Consultant to Blackstone Valley Tourism Council & Heritage Corridor, directing search of possible sunken barge in the Millville area of the Blackstone River (1996,1997).
- Designed sidescan and magnetometer survey for search and recovery of Spanish treasures of the Cortes/Moctezuma period. Veracruz, Mexico.
- W/ Ocean Surveys, Inc. A.I.D. project to transfer hydrographic mapping techniques for problematic
  shoal area of Kasai River, Zaire, Africa.

CONTINUING EDUCATION

- USCG 50 ton Masters license for Inland and Nearshore Waterways

- CPR First Aid Certified 2002
- Certified instructor computer based data sensors, Pasco Scientific, Rosedale California (1998).
- Certified user and trainer of SIS 1000 seafloor mapping system, Datasonics, Inc. (1997).
- Completed training on CARIS HIPS/SIPS on NT & Digital Chart Production on NT (1999)
- 40-hr OSHA certified with annual /8hr refreshers since 1988)
- Attended Training for TEI ISIS/Delph Map software

COMMUNITY SERVICE

- VOLUNTEER DIRECTOR OF THE POCOMOKE RIVER DISCOVERY CENTER
- CHAIR, PLAINVILLE SCHOOL COMMITTEE, PLAINVILLE, MASSACHUSETTS, 1997/1998.
- Coach, 12 & under, 11 vs. 11 soccer, Plainville Youth Soccer League, since 1992.
- Commendation from Plainville Police Department for role in a life-threatening situation, 1997.
- Science Fair Judge, Smithfield High School, 1997.
- Judge for Presidential Award Panel for Secondary Science of Rhode Island, 1997& 1998.
- Volunteer with the Hole in the Wall Gang Camp for children with life threatening diseases, since 1991.
- Participated in Boston to NY AIDS ride from Boston to New York, 1996.
- Participated in "Most Wanted Lock-Up" on behalf of Muscular Dystrophy, 1996.
- Participated as judge of Harvard-Radcliffe Club of Rhode Island Teacher Career Enhancement
- 1998: Founding Director Blackstone River Watershed Council of Rhode Island

Appendix A-4

Parker MacCready

Phone (206) 685-9588
email parker@ocean.washington.edu
URL www.ocean.washington.edu/people/faculty/parker/

Education

1982 B.A., Yale University
1986 M.S., California Institute of Technology (Engineering Science)
Advisor: Dr. T. Y.-T. Wu
1991 Ph.D., University of Washington (Physical Oceanography)
Thesis: Frictional Slowing of Rotating, Stratified Flow along a Sloping Boundary
Advisor: Dr. Peter B. Rhines

Employment

2001-present	Associate Professor, University of Washington
1994-2001	Research Assistant Professor, University of Washington
1993-1994	Research Scientist, University of Washington
1991-1993	Postdoctoral Fellow, University of Miami
1987-1991	Research and Teaching Assistant, University of Washington
1986-1987	Research Assistant, California Institute of Technology
1977-1985	Aeronautical Engineering Technician, AeroVironment Inc.

Bibliography

Refereed

MacCready, P., and P. B. Rhines 1991: Buoyant inhibition of Ekman transport on a slope and its effect on stratified spin-up, *J. Fluid Mech.,* **223**, 631-661.

MacCready, P., and P. B. Rhines 1993: Slippery Bottom Boundary Layers on a Slope, *J. Phys. Oceanogr.,* **23,** 5-22.

Garrett, C., P. MacCready, and P. B. Rhines 1993: Boundary Mixing and Arrested Ekman Layers: Rotating, Stratified Flow Near a Sloping Boundary, *Ann. Rev. Fluid Mech.,* **25**, 291-323.

MacCready, P. 1994: Frictional Decay of Abyssal Boundary Currents, *J. Mar. Res.,* **52,** 197-217.

MacCready, P. 1999: Estuarine Adjustment to Changes in River Flow and Tidal Mixing, *J. Phys. Oceanogr.,* **29,** 708-726.

MacCready, P., W. E. Johns, C. G. Rooth, D. M. Fratantoni, & R. A. Watlington 1999: Overflow into the Deep Caribbean: Effects of Plume Variability. *J. Geophys. Res*., **104**, 25913-25935.

Hickey, B. M., P. MacCready, E. Elliott, and N. B. Kachel, 2000: Dense saline plumes in Exuma Sound, Bahamas. *J. Geophys. Res.*, **105**, 11471-11488.

MacCready, P., and P. B. Rhines (2001) Meridional Transport Across a Zonal Channel: Topographic Localization. *J. Phys. Oceanogr.*, **31**, 1427-1439.

MacCready, P. and W. R. Geyer (2001) Estuarine Salt Flux Through an Isohaline Surface. *J. Geophys. Res.*, **106**, 11629-11637.

MacCready, P. and G. Pawlak (2001) Stratified Flow along a Rough Slope: Separation Drag and Wave Drag. *J. Phys. Oceanogr.*, **31**, 2824-2839

MacCready, P. and P. Quay (2001) Biological Export Flux in the Southern Ocean Estimated from a Climatological Nitrate Budget. *Deep-Sea Res.*, **49**, 4299-4322.

Pawlak, G. and P. MacCready (2002) Oscillatory flow across an irregular boundary. *J. Geophys. Res.*, **107,** 4-1 to 4-17.

MacCready, P., R. D. Hetland, and W. R. Geyer (in press): Long-Term Isohaline Salt Balance in an Estuary. PECS issue of *Continental Shelf Res.*

Honors and Awards

1997-2002	Office of Naval Research/University of Washington Scholar of Oceanography Award (with Mike Gregg, SECNAV/CNO Chair of Oceanography)
1991-1993	Rosenstiel Post-Doctoral Fellowship, University of Miami
1989	Outstanding Student Paper Award, American Geophysical Union, Ocean Sciences

University Service

School of Oceanography

1996-1999	Member, Academic Affairs Committee
1995-1996	Member, Faculty Council
2002	Organized Oceanography Seminars: Coastal and Estuarine Studies

University

2000 Speaker, Honor Student Invitational (UW Admissions Office)

Professional Offices, Awards, Service

National Committees and Related Activities

2001 Invited Participant, ONR Ocean Acoustic Meeting, Dallas, TX, January
1998 Panelist, NSF Ocean Sciences, Physical Oceanography
1997 Speaker and participant, NSF APROPOS Workshop (Advances and Primary Research Opportunities in Physical Oceanography Studies)

Washington State Agency

1995-1998 Washington State Dept. of Ecology (reviewing annual data reports)
1997 Invited Panelist, Scientific Review for LOTT (Lacey Olympia Tumwater Thurston) Budd Inlet Sewage study, Washington State Dept. of Ecology

Professional society

2000 Convener, AGU Ocean Sciences Special Session: "Flow over Rough Topography" (Kurt Polzin, co-Convener)
2000 Convener, AGU Fall Meeting Special Session: "Estuarine Circulation, Mixing, and Modeling" (Rocky Geyer, co-Convener)
2002 Program Committee Member for Estuarine Research Federation 2003 Meeting

Reviewer

National Science Foundation (Physical Oceanography, Biological Oceanography, Career, Polar Programs, and Ocean Instrumentation)
CALFED
California Sea Grant

AGU Coastal and Estuarine Studies Series
ASCE Journal of Waterway, Port, Coastal and Ocean Engineering
Continental Shelf Research
Deep-Sea Research
Eos, Trans. AGU
Estuaries
Journal of Fluid Mechanics
Journal of Geophysical Research

Journal of Marine Research
Journal of Physical Oceanography
Limnology and Oceanography

Invited Seminars

1992	Florida State University, Flow into the Deep Caribbean
1996	University of Chicago, Meridional Circulation across the ACC
1997	NSF APROPOS Conference, In Shallow Water: Basic vs. Applied Science, 'respondent' talk for Coastal session
1998	Puget Sound Research '98 Conference, Numerical Circulation Modeling as a Tool for Harmful Algae Bloom Research and Prediction
1999	JGOFS Data Workshop #2, A Diagnostic Budget of Heat and Nitrate in the Southern Ocean Mixed Layer: The "Canonical" View from Climatologies
2000	EPOC Meeting, Stratified Flow Along a Rough Slope: Separation Drag and Wave Drag
2002	Ocean Sciences AGU Meeting, Estuarine Adjustment and Sensitivity
2002	Bergen University, Bjerknes Lecture, Boundary Effects on Ocean Circulation

Professional society membership

American Geophysical Union
American Meteorological Society
Estuarine Research Federation
Pacific Estuarine Research Society.

Field Experience

1992	R.V. Columbus Iselin, Caribbean Sea
1996-	Strait of Juan de Fuca, Willapa Bay, Puget Sound

Instructional Activities

Courses Taught

Undergraduate:

Course #	Title (credits) (co-Instructor)	Date	Enrollment	Rating
GenSt 197h	Tides, Twisters and Gyres (2) (Rhines)	1998(W)	14	3.9

HA&S 222	Sewage, Science, and Society (5)	2001 (Sp)	18	4.91

Graduate:

Course #	Title (credits) (co-Instructor)	Date	Enrollment	Rating
OCN 548	Dynamics of Estuaries (3) (Gregg)	1994 (F)	7	3.85
OCN 569	Dynamics of Estuaries (3) (Gregg)	1995 (F)	5	4.1
	PO Grad Student Research Seminars, (1)	1996 (Sp)		
	PO Grad Student Research Seminars, (1)	1996 (F)		
OCN 501	Estuarine Circulation and Mixing (3) (Gregg)	1996 (F)	4	4.2
OCN 501	Estuarine Circulation and Mixing (3) (Gregg)	1999 (W)	7	4.23

Graduate Students Advised Currently

Member, Committees for (in option) *current*

Fritz Stahr	PhD	1994-1998	reading committee
Jody Klymak	PhD	1995-2001	reading committee
Xuemei Zhang		1995-1997	
Jen MacKinnon	*MS*	*1996-*	
Gabe Vecchi	MS	1996-1997	
Steve Goodson	MS	1996-1997	
Liz Elliott		1996-1997	
Sim Larkin	PhD	1996-2000	reading committee
Jonathan Lilly	MS	1996-1997	
Leif Thomas		*1997-*	
Sean Schenk	MS	1997-1999	
Alana Althaus	*MS*	*1998-*	
Neil Banas	*MS*	*1998-*	
Andrew Chiodi	*MS*	*1998-*	
Amanda Babson		*1999-*	

Member, Committees for (out of option or School)

Jim Barnard (Mech. Eng.)	PhD	1995-2000	reading committee
Carol Lee (BioO)	PhD	1998	
Micaela Schnitzler (BioO)	MS	1998	
Cynthia Cudaback (Geophys.)	PhD	1998	
Beth Mullenbach (MG&G)	*MS*	*1998-*	

Chair, Committees for

Wayne Martin 1999-
(Supported by ONR grant, and self, MS anticipated ~Summer 2002)
Ryan McCabe 2000-
(Supported by ONR and RRF grants)

Chair, Committees for Graduate Students Advised in Past

Dawn Ring	1996
Julian Douglass	1996-97
Tiangang Yu	1998-99

Postdoctoral Associates Advised Currently or in the past

Geno Pawlak	1998-2000 (Now on the faculty at Univ. Hawaii)
Kate Edwards	2000-2002 (Going to APL)

Funded Research

"Oceanic General Circulation: Combined Forcing by Stress and Buoyancy", with Peter Rhines PI, NSF, $793,406, 6/15/93-6/14/96 (21 mo).

"Meridional Circulation in the Deep Caribbean Driven by an Overflow Plume", with Peter Rhines 0% PI, NSF, $106,000, 6/1/94-11/30/96 (12 mo).

"Meridional Transport Across the Antarctic Circumpolar Current", NSF, $213,500, 7/1/96-6/30/99 (12 mo).

"Physical and Biological Controls of CO_2 Levels in the Southern Ocean: A Multi Tracer Approach", Paul Quay PI, NSF-JGOFS, $200,000, 8/1/96-7/31/98 (4 mo).

"Boundary Stress Over Rough Topography", ONR, $95,000, 10/1/97-9/30/99 (10 mo).

"Boundary Stress Over Extreme Topography", Mike Gregg PI, SECNAV/CNO Chair and ONR Scholar Program, $1,800,000, 6/1/97-3/14/02 (27 mo).

"CISNet In Situ and Remote Monitoring of Productivity and Nutrient Cycles in Puget Sound", with Al Devol, Steve Emerson, and Mary Jane Perry (UW) and Jan Newton (WA Ecology), NASA & EPA/NOAA, $581,876, 10/1/98-9/30/01 (0 mo.).

"Natural variability of the physical environment and its effect on the marine ecosystem of Willapa Bay", with Barbara Hickey PI (UW Oceanography) and David Armstrong (UW Fisheries), Washington State Sea Grant, $175,000, 6/1/99-11/30/00, (0.75 mo).

"Ocean-Estuarine Coupling and Material Processing by Oysters", with David Armstrong and Curtis Roegner (UW Fisheries), Barbara Hickey (UW

Oceanography), PM, Jennifer Ruesink (UW Zoology), Brett Dumbauld (WA DFW), and Jan Newton (WA DOE), Washington State Sea Grant, $478,702, 1/1/01-12/31/03, (2.5 mo).

"Observations of Tidal Headland Eddies in Deep Water," with Geno Pawlak (UH), NSF, $310,000, 3/1/01-2/29/04, (8 mo.).

"Estuarine Adjustment and Sensitivity," NSF, $256,513, 1/16/2002-2/28/2005, (15 mo.).

"Development of a Prototype Robotic Drifter Boat," UW Royalty Research Fund, $27,264, 3/16/2002-3/14/2003, (0.25 mo.).

Appendix A-5

Michael J Mickelson

Massachusetts Water Resources Authority, 100 First Ave, Boston MA 02129
(617)788-4746 mike.mickelson@mwra.state.ma.us
http://www.mwra.state.ma.us/harbor/enquad

Education

Ph.D. Biophysics, The University of Rochester. NDEA Title IV Fellow
B.S. Physics, Antioch College

Relevant experience

Program Manager, Outfall Monitoring, Massachusetts Water Resources Authority (1990 – present). Manage the monitoring program (annual budget of $3.5 million and 30 external staff) to detect environmental effects of Boston's sewage effluent outfall in Massachusetts Bay. Inspire public, scientific, and regulatory confidence that the monitoring program is environmentally protective yet efficient and well-focused. Plan, coordinate, and disseminate the collection, analysis, and results of environmental receiving-water data. Define the responsibilities and scope of technical and environmental studies related to the Boston Harbor cleanup.

Senior Marine Scientist, Marine Science Laboratories, Department of Conservation and Environment, Victoria, Australia (1981-1990). Determine marine impact of Melbourne's sewage discharge on dissolved oxygen and seagrass. Correlate penguin mortality to oceanographic and meteorological variables.

Advisory bodies and invited workshops

Gulf of Maine Ocean Observing System, member of Board of Directors (2000-present)
National Ocean Observing Systems, participant at NOAA-EPA workshop (Maryland 1999)
Autonomous Underwater Vehicles, participant at SeaGrant workshop (England 1996)
Consultative Committee, Geelong and District Water Board (Australia 1988).

Selected publications

Indicator-based monitoring of a coastal wastewater discharge in Boston Massachusetts. Mickelson MJ, Hunt CD, Roberts PJW. 2nd International Conference on Marine Waste Water Discharges; Sept. 16-20, 2002; Istanbul. MWWD. p 8.

Field and model studies of the Boston outfall. Roberts PJW, Hunt CD, Mickelson MJ. 2nd International Conference on Marine Waste Water Discharges; Sept. 16-20, 2002; Istanbul. MWWD. p 17.

MWRA's Massachusetts Bay Outfall. Connor MS, Rex AC, Mickelson MJ, Keay KE, Leo WS. 1998. Environment Cape Cod 1(3): 1-13.

Growth of the seagrass Heterozostera tasmanica limited by nitrogen in Port Phillip Bay, Australia. Bulthuis DA, Axelrad DM, Mickelson MJ. 1992. Mar. Ecol. Prog. Ser. 89(2-3), 269-275.

Effect of southern Oscillation, wind, and sea temperature on breeding of the Little Penguin *Eudyptula minor* at Phillip Island, Victoria, Australia. Mickelson MJ, Dann PM, Cullen JM. 1992. Emu 91: 355-368.

Inexpensive in situ time-integrating seawater nutrient sampler. Mickelson MJ, Axelrad DM, Longmore AR, Critchley GW. 1986. Water Research 20:1457-1459.

Light and nutrient status of algal cells. Droop MR, Mickelson MJ, Scott JM, Turner MF. 1982**.** J. Mar. Biol. Ass. U.K. 62:403-434.

Marine phytoplankton ecology: Test of nutrient based hypothesis using continuous cultures. Mickelson MJ 1980. Contin. Cultiv. Microorganisms, Proc. 7th Symp. Prague, July 10-14, 1978; Prague 1980 pp 403-408.

Nutrient determined dominance in multispecies chemostat culture of diatoms. Mickelson MJ, Maske H, Dugdale RC. 1979**.** Limnology and Oceanography 24:298-315.

Coastal-inland solar radiation differences in Maine. Mickelson MJ. 1978. Maine Biologist 10:3-8.

Solar radiation in Peru during Joint-II: A guide for modelers. Mickelson MJ. 1978. Coastal Upwelling Ecosystems Analysis Technical Report No. 43. 42Pp.

Enterotoxigenic intestinal bacteria in tropical sprue. IV. Effect of linoleic acid on growth interrelationships of Lactobacillus acidophilus and Klebsiella pneumoniae. Mickelson MJ, Klipstein FA. 1975. Infection and Immunity 12:1121-1126.

Selected technical reports

2001 annual water column monitoring report. Libby PS, Geyer WR, Keller AA, Turner JT, Borkman D, Mickelson MJ, Hunt CD, Oviatt CA. Turner JT. Boston: Massachusetts Water Resources Authority. Report ENQUAD 2002-xx. Draft.

Combined work/quality assurance plan (CWQAPP) for water column monitoring 2002 - 2005 - tasks 9, 10, 12, 13, 14, 15. Libby PS, Gagnon C, Albro CS, Mickelson MJ, Keller AA, Borkman D, Turner JT, Oviatt CA. Boston: Massachusetts Water Resources Authority. Report ENQUAD ms-074. 79 p.

Massachusetts Water Resources Authority Outfall Effluent Dilution: July 2001. Hunt CD, Mansfield AD, Roberts PJW, Albro CA, Geyer WR, Steinhauer WS, Mickelson MJ. Boston: Massachusetts Water Resources Authority. Report 2002-07. 77 p.

Outfall monitoring overview report: 1996. Gayla DP, *et al*. Boston: Massachusetts Water Resources Authority. Report ENQUAD 1997-08. 57p.

Wastewater discharges to Massachusetts Bay: environmental monitoring changes the problem definition. (1994) Connor MS, Mickelson MJ, Keay KE. Water Environment Federation conference proceedings p 469-480, Alexandria.

Massachusetts Water Resources Authority Contingency Plan: Outfall Simulation Plans for Deer Island Treatment Plant. Coughlin K, Mickelson MJ. Boston: Massachusetts Water Resources Authority. Report ENQUAD 2000-18. 30 p.

<u>Appendix A-6</u>

Philip J.W. Roberts, PhD, PE

Professor of Civil and Environmental Engineering, Georgia Institute of Technology

Education

PhD Environmental Engineering Science, California Institute of Technology, 1977
MS Environmental Engineering Science, California Institute of Technology, 1972
SM Mechanical Engineering, Massachusetts Institute of Technology, 1970
BSc (Eng) Mechanical Engineering, Imperial College of Science and Technology, University of London, 1968 First Class Honors.

Awards And Professional Qualifications

UPS Foundation Visiting Professor, Stanford University, 1993-94.
1980 Collingwood Prize of ASCE for paper: "Line Plume and Ocean Outfall Dispersion."
Fellow, American Society of Civil Engineers.
Adjunct Professor of Oceanography, Skidaway Institute of Oceanography, Georgia.
Associate Editor, Journal of Hydraulic Engineering, 1987 to 1992.
Member of the Hydrologic Transport and Dispersion Committee, ASCE, 1988 to present.
Chairman of the ASCE Hydraulics Division Research Committee, 1986-1987.
Co-Chairman, Specialist Group on Marine Wastewater Disposal, International Water Association.

Key Qualifications

Dr. Roberts is an authority on the fluid mechanics of outfall diffuser mixing and the development and application of mathematical models of wastewater fate and transport. He has extensive international experience in marine waste disposal including the design of ocean outfalls, review of schemes, numerical modeling, and oceanographic fieldwork program design and data interpretation. His mathematical models and methods have been adopted by the U.S. EPA and are widely used. He is a regular lecturer at the EPA Mixing Zone Workshops on the use of mathematical models and on outfall design for the Pan American Health Organization. He conducts research on diffuser mixing processes and has published extensively in this area. For this research he was awarded the Collingwood Prize of ASCE in 1980, and was UPS Foundation Visiting Professor at Stanford University in 1993-94. Dr. Roberts has lectured widely on outfall design around the world and is presently Co-Chairman of the Specialist Group on Marine Wastewater Disposal, International Water Association, London. He was also responsible for the physical modeling of dilution for the Boston tunneled outfall diffuser. This outfall was commissioned in September 2000 and is the worlds largest.

Some Recent Consulting Activities

Bechtel Corporation, San Francisco: Mathematical and physical modeling of mining tailings outfall.

World Bank, Washington, DC: Member of expert panel to review outfall scheme in Cartagena, Colombia. Also mathematical modeling of Cartagena outfall.

CH2M Hill, San Francisco: Field tests and numerical modeling for San Francisco ocean outfall.

Ministry for the Environment, New South Wales, Australia: Reviewed of ocean outfall program of Sydney, Australia.

Engineering-Science, La Jolla, California: Dilution calculations for proposed San Diego Outfall.

AB2H Consultants, Hong Kong: Preliminary design of Hong Kong tunneled outfall diffuser.

ICF Kaiser Engineers, Rio de Janeiro. Design of Alegria outfall and field data collection program.

PB/CH2M Joint Venture: Numerical modeling and design of outfalls for Singapore.

World Bank, Washington, DC: Design and modeling of ocean outfalls for Dominican Republic.

STE, Rio de Janeiro, Brazil: Design of Ocean Outfall for City of Rio de Janeiro.

Hydraulic & Water Resources Engineers, Waltham: Review of internal hydraulics, Boston outfall.

CETREL, Salvador, Brazil: Design and oceanographic studies for petrochemical outfall.

TAHAL Consulting Engineers, Tel Aviv: Outfall design for dense effluent into Mediterranean Ocean.

Multiservice Engenharia, Sao Paulo, Brazil. Rehabilitation design of Santos outfall.

Massachusetts Water Resources Authority: Field tests of Boston outfall

Some Recent Research Grants and Contracts

"Hydraulic Model Studies of Boston Wastewater Outfall," Massachusetts Water Resources Authority.

"Energetics of Jet- and Plume-Induced Turbulence in Stratified Fluids," National Science Foundation.

"Laser-Induced Fluorescence Imaging of Laboratory Dredge Spoil Dispersion Experiments," U.S. Army Corps of Engineers, Waterways Experiment Station.

"Initial Dilution Study," Mamala Bay Study Commission, Hawaii.

"Chemical Information Content of Chemical Odor Plumes," DARPA, Office of Naval Research.

"Hydrodynamics of Mixing of Wastewater Discharges," U.S. EPA Office of Exploratory Research.

"Development of Mathematical Models for Beach Pathogens," U.S. EPA

Book Chapters

Roberts, P. J. W. "Ocean Outfall Design Considerations," in "*Ocean Engineering Science: The Sea, Volume 9*," B. Le Mehaute and D. M. Haines, Eds., John Wiley and Sons, 1990.

Roberts, P. J. W. "Mixing and Transport in Natural Streams," in *"Encyclopedia of Fluid Mechanics, Volume 10*." N. P. Cheremisinoff, Ed., Gulf Publishing, 1990.

Roberts, P. J. W. (1996). "Sea Outfalls." In "*Environmental Hydraulics,"* V. P. Singh and W. Hager, eds., Kluwer Academic Publishers, Dordrecht.

Ettema, R., Arndt, R., Roberts, P. J. W., and Wahl, T. (2000). "Hydraulic Modeling: Concepts and Practice." ASCE, Reston, Virginia.

Roberts, P. J. W., and Webster, D. R. (2002). "Turbulent Diffusion." In *Environmental Fluid Mechanics - Theories and Applications*, ASCE.

Selected Publications

Roberts, P. J. W., Snyder, W. H. and Baumgartner, D. J. (1989), "Ocean Outfalls: Parts I, II, and III", *Journal of Hydraulic Engineering*, ASCE, Vol. 115, No. 1, pp. 1-70.

Roberts, P. J. W., and Snyder, W. H. (1993). "Hydraulic Model Study for the Boston Outfall. Parts I and II," Jo*urnal of Hydraulic Engineering, ASCE*, 119(9): 970-1002

Baumgartner, D. J., Frick, W. E., and Roberts, P. J. W. (1994). "Dilution Models for Effluent Discharges (Third Edition)." *U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC.* EPA/600/R-94/086.

Roberts, P. J. W., and Ferrier, A. (1996). "Understanding Mixing Zones." *Water Environment & Technology*, 8(7), 39-43.

Roberts, P. J. W., Ferrier, A., and Daviero, G. (1997). "Mixing in Inclined Dense Jets." *Journal of Hydraulic Engineering, ASCE,* 123(8), 693-699.

Roberts, P. J. W., and Sternau, R. F. (1997). "Mixing Zone Analysis for a Coastal Wastewater Discharge." *Journal of Environmental Engineering*, ASCE, 123(12), 1244-1250.

Roberts, P. J. W. (1999). "Modeling the Mamala Bay Plumes. Parts I and II." *Journal of Hydraulic Engineering, ASCE*, 125(6), 564-583.

Daviero, G. J., Roberts, P. J. W., and Maile, K. (2001). "Refractive Index Matching in Large-Scale Stratified Experiments." *Experiments in Fluids*, 31, 119-126.

Frick, W. E., Roberts, P. J. W., Davis, L. R., Keyes, J., Baumgartner, D. J., and George, K. P. (2002). "Dilution Models for Effluent Discharges, 4th Edition (Visual Plumes) Draft." U.S. Environmental Protection Agency, Environmental Research Division, NERL, Standards and Applied Science Division, Office of Science and Technology, Athens, Georgia.

Roberts, P. J. W., Maile, K., and Daviero, G. (2001). "Mixing in Stratified Jets." *Journal of Hydraulic Engineering, ASCE*, 127(3).

Webster, D. R., Roberts, P. J. W., and Ra'ad, L. (2001). "Simultaneous DPTV/PLIF measurements of a turbulent jet." *Experiments in Fluids*, 30, 65-72.

Carvalho, J. L. B., Roberts, P. J. W., and Roldao, J. (2001). "Field Observations of the Ipanema Beach Outfall." *Journal of Hydraulic Engineering, ASCE,* 128(2), 151-160.

Roberts, P. J. W., and Tian, X. (2002). "New Experimental Techniques for Validation of Marine Discharge Models." To be published, *Journal of Marine Systems*.

Invited Presentations

Roberts, P.J.W. and Williams, N. (1991), "Modeling of Ocean Outfall Discharges," IAWPRC International Conference on Marine Disposal Systems, Lisbon, Portugal, 20-22 November.

Roberts, P.J.W. (1992), "Modeling Ocean Outfalls," Plenary Speaker, National Heat Transfer Conference, ASME, San Diego, August 8-12.

Roberts, P.J.W. (1992), "New Instrumentation for Stratified Flow Experiments," Institute of Mathematics and its Applications, Fourth Conference on Stably Stratified Flows, Surrey, England, September 21-23.

Roberts, P.J.W. (1993), "Jets and Plumes and Ocean Outfall Design," NATO Advanced Research Workshop on Turbulent Jets and Plumes, Portugal, June 28 - July 2.

Roberts, P.J.W. (1993), "Fluid Mechanics Aspects of Ocean Outfalls," National Conference on Hydraulic Engineering, San Francisco, July 25-30.

Roberts, P. J. W. (2001) "Turbulent Jets and Plumes Applied to Ocean Outfalls." Invited Keynote Address, 3rd International Environmental Hydraulics Symposium, Tempe, Arizona, Dec. 5-8.

APPENDIX B

TECHNICAL REVIEWS

APPENDIX B-1

Core Subject Area →	**Physical Oceanography**
MOSS Technical Documents Reviewed →	1. *Review: Puget Sound Physical Oceanography Related to the Triple Junction Region. January 2001*
	2. *Interim Report: Puget Sound Physical Oceanography Related to the Triple Junction Region, Phase 2. September 2001*
	3. *Final Report: Puget Sound Physical Oceanography. November 2002*
Peer Reviewer →	**Parker MacCready,** Ph.D., Oceanographer, University of Washington

Document 1. *Review: Puget Sound Physical Oceanography Related to the Triple Junction Region.*

Coordinator's Summary

The individual peer reviewer examined the three oceanographic technical documents and provided comments throughout. These are summarized below in numerical order.

A comprehensive review of previous studies completed by researchers who conducted much of the original work. The reviewer commented specifically on three items. First, the Figure 2 flow schematic displayed better clarity for some of the same information reported in Figures 95 through 98 of the final oceanography report, and "could serve a model for revising those figures."

Next, Figure 3B illustrated "an important way of presenting results," and a revised version should be included as one of the "Flow Schematics" in the final oceanographic document. This version should highlight the "flow pathways which may take water from the outfall sites into Whidbey Basin."

Lastly, Figure 10 illustrated water quality problems in Whidbey Basin, and while the reviewer did not think "additional nutrients from a new outfall near Edwards or Wells Point would enhance this eutrophication, it [would] be important to make this calculation explicit." "Plotting properties just on a fixed depth" should be avoided because dissolved oxygen minimum depths may differ between the Main Basin and Whidbey Basin.

Document 2. *Interim Report: Puget Sound Physical Oceanography Related to the Triple Junction Region, Phase 2.*

See below.

Document 3. *Final Report: Puget Sound Physical Oceanography. November 2002*

General

Measurements of current and density "near the shore to the North of these [outfall] sites, and up into Whidbey Basin" should have been more extensive. The reviewer felt "this is the flow pathway with the greatest likelihood of causing environmental damage," but stated that the "measurements [taken] can only give hints about the nature of this pathway."

"The observations and initial data processing are generally of high quality, holding to good professional standards for scientific research of this type." The "Flow Schematics" illustrated in Figures 95 through 98 of the Phase 3 document "are absolutely crucial in the task of conveying the information of this project to anyone who is not a physical oceanographer."

It should be specified if and why one calendar season might be more important than another with respect to "sewage conveyance." Also, the meaning of the word "phase" should be clarified (i.e., direction of flow or timing of tidal currents).

Methods

An adequate number of current meters were deployed for a length of time that is appropriate for "strongly tidal situations." However, additional current meters placed "on the sloping sidewalls on the East side" of Possession Sound section would have been more favorable "given the possibility ... that flow at all depths may be going northward there." To achieve "better continuity in time and space," the reviewer suggested "deploying all the instruments [during the summer months] in a pattern around Wells and Edwards Points…and up into Possession Sound." Also, S4's could provide added data along channel sides.

A "gimballed bottom bracket" should have been used in steep slope regions of the Sound, and could have prevented the loss of ADCP data. Also, the use of "drifters drogued up to depths of 150 m" should be discussed further, and a "line diameter, calculation of the drag terms, or a reference for the use of such deep drogues" should be provided.

Current Meter Observations

The reviewer agreed strongly with the authors that the complex tidal currents "render [ed] the tidal ellipses somewhat meaningless." Therefore, the use of "modes" when representing tidal currents was "reasonable, justified, and much more informative than any other method I have come across." Figures 6 through 9 illustrated clearly the tidal flow "particularly in the convergence/divergence region just north of Edwards Point."

Data do not entirely support the author's conclusion that the "major flow" in the Edwards Point section was "directed toward Admiralty Inlet." For example, Figures H1 and H2 illustrated "many of the nearby current meters show [ed] flow toward Whidbey Basin."

Drifter Observations

The percentage of drift cards moving “from the mouth of Possession Sound northward” (Whidbey Basin) should have been reported somewhere in Table 7. Also, some changes to the drifter plots would improve legibility.

The author’s were “puzzle [ed] … that no deep drogues were observed to enter Possession Sound.” The reviewer suggested that too few drogues, a brief deployment, and drogues “below the inflow depth … at those times” as possible explanations. Further, the drogue data appeared “too sparse” to support the implied conclusion that deep water does not enter Possession Sound. As illustrated in Figure 96, the “current meter data suggest [ed] that deep flow does enter Possession Sound.”

Analysis and Discussion

An extremely dry winter study period could weaken the estuarine circulation “relative to average conditions.” Such an issue should be reported “more prominently, perhaps in the Executive Summary.” Also, “a two-layer box model … could be used to see what effect a dry year might have on the flow from Main Basin into Whidbey Basin.”

The number of drogues appeared insufficient for a dispersion analysis, and should have included some “error estimates on the final dispersion coefficient.” Also, the final result should be explained.

The reviewer felt the author’s statement regarding northerly wind effects enhancing flow into Possession Sound was important and should be discussed further. The results of the different flow transport in Table 14 should also be covered more thoroughly, “presumably from a sewage disposal perspective.”

Flow Schematic Figures

Figures 95 through 98 were discussed separately. For each, graphical clarity, legibility, and color scheme was discussed. The significance of the length and thickness for arrow lines was questioned in Figures 97 and 98.

The currents illustrated in Figure 96 represented depths when at times “all the sewage from the new outfall will be cycled slowly through Whidbey Basin before it is flushed out to Juan de Fuca.” The reviewer stated “this conclusion is reasonably supported by the current meter data, and should be made very clear in the Executive Summary.”

Oceanography Documents 1, 2, and 3.

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Review of Physical Oceanography documents for King County Brightwater Project

February 24, 2003

Reviewer:

Parker MacCready, Ph.D.
Associate Professor
University of Washington
Oceanography, Box 355351
Seattle, WA 98195-5351
Phone: (206) 685-9588 (UW), (360) 956-3216 (Olympia)
Email: parker@ocean.washington.edu

General Comments:

The scientific studies described in these documents present results and analysis of a large number of observations of currents and physical properties (temperature, salinity, and density) in the "Triple Junction" region of Puget Sound. Historical observations are reviewed, and new results, from July 2000 through January 2002, are presented. The researchers involved have a long history of work in Puget Sound; this is particularly true of Glenn Cannon and Curt Ebbesmeyer.

The review of previous work, Doc. 1 [Phase 1 report], was quite thorough. Indeed, much of the previous work was done by the researchers writing the review. Most of the references were at least 10 years old, but that reflects a hiatus in Puget Sound research. Much work has been done recently, but has not yet been published in the refereed literature.

The sampling scheme of the current work, Docs. 2 & 3 [Phase2 and 3, respectively], was focused on issues relevant to the dispersal of sewage introduced near Pt. Wells or Pt. Edwards. However there was also considerable effort put into characterizing the overall circulation patterns in the region. In retrospect, greater emphasis should have been placed on current and density measurements close to the proposed outfall sites, near the shore to the North of these sites, and up into Whidbey Basin. In my view this is the flow pathway with the greatest likelihood of causing environmental damage, but the measurements can only give hints about the nature of this pathway.

The observations and initial data processing are generally of high quality, holding to good professional standards for scientific research of this type. The subsequent analysis of the observations is summarized in the four "Flow Schematics," Figures 95-98 of the final report (Doc. 3). These are absolutely crucial in the task of conveying the information of this project to anyone who is not a physical oceanographer. These could be improved in some ways, as suggested below.

Detailed Comments:

Document 1: Review: Puget Sound Physical Oceanography Related to the Triple Junction Region, Phase 1.

In many respects the flow schematic shown in Fig. 2 conveys similar information to Figures 95-98 of the final report (Doc. 3), but it is much clearer. This could serve as a model for revising those figures.

Figure 3B, a vertical section of the mean flow through Main Basin and Whidbey Basin, is also an important way of presenting results. A revised version of this figure should be made one of the Flow Schematics in the final report. Such a figure should pay particular attention to the flow pathways which may take water from the outfall sites into Whidbey Basin.

Figure 10 is a striking demonstration of the water quality problems (low DO) in Whidbey Basin. Although I doubt that the additional nutrients from a new outfall near Edwards or Wells Points would enhance this eutrophication, it will be important to make this calculation explicit. Also, an updated version of this figure would be welcome. One important point about this figure is that it plots properties at the depth of the DO minimum. I suspect that this depth, and the depth at which the inflowing limb of the estuarine circulation occurs, is deeper in Main Basin and shallower in Whidbey. This argues against plotting properties just on a fixed depth (as in Figures 95-98 of the final report, Doc. 3).

Page 29, third bulleted question. The issue of when water goes from main Basin into Possession Sound is a good one.

Document 2: Interim Report: Puget sound Physical Oceanography Related to the Triple Junction Region, Phase 2

The information in this report is all recapitulated in Doc. 3, so refer to the comments below.

Document 3: Puget sound Physical Oceanography Related to the Triple Junction Region, Phase 3 (final)

Page 1, first paragraph. It should be made clear if one season is considered to be more important than another, and why, as far as sewage conveyance is concerned.

Page 2, section 1.2, first paragraph. Throughout the report I found the use of the word "phase" to be confusing. What is intended is to convey the idea that the tidal currents do not flow exactly in opposite *directions*. But in the literature the word "phase" almost always refers to a difference in *timing* of the tidal currents.

Page 3, last paragraph. In Bretschneider et al. (1985) it appears that there is northward flow near the top of East Passage.

Page 5. Deploying the current meters for a month or more is good practice for strongly tidal situations, and this was followed here. It would have been nice to have more coverage near the sides of the Possession Sound section. The number of current meters used was comparable to other coastal studies. ADCP's are expensive. The strategy the researchers used to get good spatial coverage was to deploy all they had (excluding the instruments devoted to the year-long stations) on single sections at a time for 1-3 months duration. As they point out, this makes it hard to directly compare one section with another. If the study was being done again I would advocate deploying all the instruments in a pattern around Wells and Edwards Points, in the near field of the Triple Junction, and up into Possession Sound. This would give less-resolved sections, but much better continuity in time and space. Then EOF analysis could be done as a way to make sense of the results. You would probably want to try this over a 3-6 month period during the summer, since that is the time when winds from the north occur most often. Later (e.g. Fig. 97) it is shown that northerly winds are associated with a near surface northward flow near the shore, from Pt. Wells into Possession sound. The S4's could be deployed near the surface on the channel sides to cover what the ADCP's can't see there.

Page 6, top. The loss of ADCP data due to a sloping bottom presumably is due to the lack of a gimbal on the bottom bracket. A gimballed bottom bracket is a relatively cheap investment, and allows you to use the ADCP on the sloping sides of the Sound, which are almost always steep.

Page 11, Table 4. More comment is needed on the use of drifters drogued up to depths of 150 m. 20 m is a much more standard depth. The issue is that the hydrodynamic drag of the drogue should be about 40 times that of the surface float and line (Niiler et al. 1995). Otherwise the drifter path will not properly reflect the water motion at the depth of the drogue. Please give the line diameter, and a calculation of the drag terms, or a reference for the use of such deep drogues.

Page 13, Section 3.1.1. The method of representing the tidal currents using "modes" determined from angular histograms is not a standard practice. Instead, tidal ellipses such as in Fig. 57 are used. However I strongly agree with the report authors that the complex nature of the tidal currents in the Triple Junction renders the tidal ellipses somewhat meaningless. I find that their "mode" representation is reasonable, justified, and much more informative than any other method I have come across. Very creative. The resulting figures 6-9 do a great job of showing the tidal flow, particularly in the convergence/divergence region just north of Edwards Point. Also, it was good that they did not high-pass filter the signals before doing this analysis, because that would remove the flood or ebb dominance which shows the estuarine circulation.

Page 13, Section 3.1.2. Similarly, I find the low-frequency modes to be a useful description of the flow. As I described above, it is unfortunate that they could not have had better spatial coverage over a single (long) time interval. This would have allowed an EOF analysis (maybe).

The results in Bretschneider et al. (1985) showed that such an analysis could discern between the effects of winds, tidal rectification, and intrusions for a section. Perhaps the same would prove true for a more dispersed, but synchronous, spatial sampling pattern.

Page 21, last paragraph. I think that the conclusion that the "major flow in this section is directed toward Admiralty Inlet" is not supported by views of the data elsewhere in the report. In figures H1 and H2 many of the nearby current meters show flow toward Whidbey Basin. Perhaps the difference is related to the different sampling times.

Page 22, Possession Sound Section. It would have been better to have more current meters on this section, particularly on the sloping sidewalls on the East side. This is important given the possibility suggested on Page 24 (middle) that flow at all depths may be going northward there.

Page 25. I would like to have seen statistics for what percentage of cards went anywhere in Whidbey Basin (by which I mean everywhere from the mouth of Possession Sound northward). This might mean splitting the first data column in Table 7 into two columns, one for Main Basin and one for Whidbey Basin.

Page 29, paragraph 2 of Section 4.2. At several places in the report it is repeated that it is "puzzling ... that no deep drogues were observed to enter Possession Sound." Presumably this refers to the 7 drogues shown in Figures 48 and 50. I would suggest that (i) the number of drogues was small, (ii) they weren't out very long compared to the time it takes to go into Whidbey Basin, and (iii) maybe they were below the inflow depth in Possession Sound at those times. The implication of the "puzzling" sentence is that maybe deep water doesn't go into Possession Sound, but I think that the drogue data is too sparse to reach this conclusion, and that the current meter data suggests that deep flow does enter Possession Sound (as in Fig. 96).

I would have found the drifter plots more legible if a few changes were made: (i) list the depth and duration of each drifter in the legend, (ii) make sure all starting locations are shown clearly, (iii) put dots on the trajectories every 12.42 hours, instead of at every gps fix [this might help with problem (ii)], and (iv) increase the northward axis limits on Fig. 52, so that we can see where the drifters went.

Page 33, middle. The reader would benefit from some interpretation of the importance of the figure "0.2 ppb." Is this a big number or a small number?

Page 40, near the bottom. The statement "At both depths northerly winds augmented the flow toward Possession Sound." This is an important point, and worth amplifying.

Page 45, top. I liked the nice summary statistics concerning drifter escapement.

Page 46, Table 12. It would be helpful to add a number for the volume flux into Whidbey Basin.

Page 47, below Table 14. There needs to be more discussion of these results, presumably from a sewage disposal perspective. It does little to just state that there are 5 orders of magnitude difference among the transports.

Page 48, Section 5.9. Given the complex nature of the currents in this region, the progressive vector diagrams are pretty meaningless. This part of this section could be dropped.

Page 51, top. I think that the number of drogues is too small to do a dispersion analysis. At least there should be some error estimates on the final dispersion coefficient, perhaps by recalculating it with different subsamples of the drifters (bootstrap). Also there needs to be some discussion of the final result. Is 2800 $cm^2 s^{-1}$ a big number?

Page 52, third paragraph from bottom. It is very important that the winter of the study period was the "second most severe dry period since the winter of 1976 through 1977." The implication is that the estuarine circulation may have been weak relative to average conditions. This deserves to be highlighted and discussed more prominently, perhaps in the Executive Summary. The two-layer box model developed by Babson and Kawase could be used to see what effect a dry year might have on the flow from Main Basin into Whidbey Basin.

Page 58, point 3, and Fig. 96. This current pathway from Pt. Wells into Possession Sound implies that it is likely that there will be times when all the sewage from the new outfall will be cycled slowly through Whidbey Basin before it is flushed out to Juan de Fuca. I think that this conclusion is reasonably supported by the current meter data, and should be made very clear in the Executive Summary.

Specific comments on the Flow Schematic figures:

Fig. 95. This one is reasonably clear, except that the purple in the recirculating current arrows does not match that in the legend.

Fig. 96. The current arrows are clear here. It should be emphasized that this is the depth of the diluted sewage plume, and that there is a clear pathway into Possession Sound from either outfall site. The two purple areas don't add much to the figure.

Figure 97. This needs to be simplified. What is the meaning of the short black line segments off Pt. Wells and Paine Field? Also, is arrow length proportional to flow speed? If so, what is the meaning of the longest arrow on the plot which crosses the Triple Junction to the SW? The dark blue arrows are hard to distinguish from the black. Otherwise, I really like the idea of trying to represent different wind conditions.

Fig. 98. Again, what is the meaning of the short black line segments off Pt. Wells and Paine Field? As with Fig. 97, this needs to be made easier to read. Why is there a thick double purple arrow, when all other arrows are thin? Work to make each scenario as clear as Fig. 1.

Page 63, middle. Again the "puzzling" deep drifters. See comments for page 29.

Page 63, bottom. This report ends with the same question about low DO in Whidbey Basin that the Review report had. I agree that it is a good question. Does the data in Docs. 2-5 get us any closer to answering it? At least an updated version of the DO map from the Review report would help.

Figs. 57-60. Need a scale for the ellipse velocities.

Fig. 62. The labeling of flood and ebb vector colors appears to be switched in the legend.

Figure 92. Could data from this project be added to the plot?

REFERENCES

Niiler, P. P., A. S. Sybrandy, K. Bi, P. M. Poulaine, and D. Bitterman, 1995: Measurements of the water-following capability of holey-sock and TRISTAR drifters. *Deep-Sea Res. I*, **42**, 1951-1964.

Bretschneider, D. E., G. A. Cannon, J. R. Holbrook, and D. J. Pashinski, 1985: Variability of subtidal current structure in a fjord estuary: Puget Sound, Washington. *J. Geophys. Res.*, **90**, C6, 11949-11958.

END OF MACCREADY FULL TEXT REVIEW

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

From the full text review: referring to Table 4 (page 11) in the *Final Report: Puget Sound Physical Oceanography*:

Respondent: Bruce Nairn, King County DNR

1. Please give the line diameter, and a calculation of the drag terms, or a reference for the use of such deep drogues.

> *RESPONSE: The drogue tether line was about 5mm in diameter. Thus a 100-meter line contributes nearly 20% of the drogue's drag, assuming C_D is 1.0 for both line and sail. The ability of drogues at this depth to follow the targeted water masses is subject to a greater level of error than shallower drogues.*

From the full text review: referring to Section 4.3, Dye Releases (page 33) in the *Final Report: Puget Sound Physical Oceanography*:

1. The reader would benefit from some interpretation of the importance of the figure "0.2 ppb." Is this a big number or a small number?

> *RESPONSE: 0.2 ppb is approximately 5 to 10 times our MDL, and was large in respect to the concentrations we typically observed at the shoreline sampling stations. However, the dye was released at a concentration of 1,800,000 ppb, and this is small relative to the initial concentration, representing a dilution of 9,000,000:1.*

From the full text review: referring to Section 5.10 (page 51) in the *Final Report: Puget Sound Physical Oceanography*:

1. Regarding the drogues and a dispersion analysis: Is 2800 $cm^2\ s^{-1}$ a big number? There should be some error estimates on the final dispersion coefficient.

> *RESPONSE: 2800 $cm^2\ s^{-1}$ is a diffusion coefficient typical of what is observed in the open ocean. From a characteristic cluster size of 200m, an estimate of the diffusion coefficient between 1086 and 5429 cm^2/s is obtained from the 4/3 law a constant(a) of 0.002-0.01 $cm^{2/3}/sec$, as suggested in Fischer et al.*

From the full text review: referring to Flow Schematic Figure 97 in the *Final Report: Puget Sound Physical Oceanography*:

1. This needs to be simplified. What is the meaning of the short black line segments off Pt. Wells and Paine Field? Also, is arrow length proportional to flow speed? If so, what is the meaning of the longest arrow on the plot which crosses the Triple Junction to the SW? The dark blue arrows are hard to distinguish from the black.

RESPONSE: These figures would benefit from being simplified and drawn with more clarity, as the reviewer suggests. The length of the arrows were not intended to be representative of flow speed, but to represent observed patterns of water movement. The short black line segments indicate the location of the long-term Aanderaa mooring, and the fact that the variability shown at these locations were obtained from the fixed current meters at these locations, as opposed to the lagrangian data used elsewhere.

<u>From the full text review: referring to Flow Schematic Figure 98</u> in the *Final Report: Puget Sound Physical Oceanography*:

1. Again, what is the meaning of the short black line segments off Pt. Wells and Paine Field? As with Fig. 97, this needs to be made easier to read. Why is there a thick double purple arrow, when all other arrows are thin? Work to make each scenario as clear as Fig. 1.

RESPONSE: See previous response.

<u>From the full text review: referring to Section 6.0, Summary (page 63)</u> in the *Final Report: Puget Sound Physical Oceanography*:

1. This report ends with the same question about low DO in Whidbey Basin that the Review report had. I agree that it is a good question. Does the data in Docs. 2-5 get us any closer to answering it? At least an updated version of the DO map from the Review report would help.

RESPONSE: Since the figure in the review document attempts to summarize the average of many years of data, the data this study was able to collect is likely not of a sufficient duration to determine how these averages may have changed in time. However, this is a good question that might be pursued further using the ambient monitoring data Ecology collects.

<u>From the full text review: referring to Figure 92 (Salinity anomaly, Point Jefferson: 100m)</u> in the *Final Report: Puget Sound Physical Oceanography*

1. Could data from this project be added to the plot?

RESPONSE: Figure 92 would certainly benefit from the addition of data collected during this study. However, this may not be available before the May 1 workshop.

APPENDIX B-2

Core Subject Area →	**Geology (geophysical and geotechnical)**
MOSS Technical Documents Reviewed →	1. *Marine Geophysical Investigation: Marine Outfall Siting Study. March 2001*
	2. *Brightwater Marine Outfall Conveyance System Interim Conceptual Geotechnical Assessment. May 2002*
	3. *Submarine Cultural Resources. September 2001*
Peer Reviewer →	**Douglas R. Levin,** Ph.D., Geologist, University of Maryland, Eastern Shore

Document 1: *Marine Geophysical Investigation: Marine Outfall Siting Study.*

Coordinator's Summary

General

The individual peer reviewer examined the entire technical document and provided comments throughout. Overall, an exceptional data set was gathered, however the resulting technical document "was not commensurate with the amount of field data…collected." Instead, the document appeared as an "operations review" rather than a detailed, technical account of the geology and geophysics of the candidate outfall zones. Further, the QA/QC procedures were incompletely described, data collection details were lacking, and the "data interpretation" report section was abbreviated and did not incorporate sufficient content or graphics to "illustrate the pros and cons of each site." "Conclusions and analysis were made without detailed graphical support." A literature review and "previous work done" section would have strengthened the document.

It appeared the science followed the Detailed Evaluation Questions (DEQ's) closely; therefore it is important to understand the rationale and methods for developing such criteria. The reviewer asked "who was responsible for determining these criteria and what scientific literature/work was considered to support the decisions?" "What was the rationale for the selection of study within the DEQ?"

Study design

"If the objectives were to satisfy questions within the Level One [DEQ's] then they have been considered." Criteria and justification for specific objectives (i.e., identification of 'alternative corridors…for the marine outfall, having gradual slopes and consistent and regular contours') should be stipulated.

Program design should be based on "concise scientific-based determination[s]," not "experience" factors. As an example, "justification for the line spacing should be based on expected scales of lateral facies changes and tied to the objective of the program."

Geologic references supporting route criteria were not cited in the Level 1 or Level 2 DEQ's. Also, scientific and technical references were absent in the 'regional and geologic settings' of this document.

Data collection

The data were gathered via appropriate field equipment, though the "data products" were not included in the technical document. However, program objectives were achieved because analysis of field data was adequate.

The reviewer commented on the survey instrumentation; Precision Echosounder, Side-Scan Sonar, and Sub-Bottom Profiler:

The transducer used as part of the precision echosounder equipment to obtain bathymetric data was not identified, nor was it described how data were used. The proper system was employed for the depth range, however "the bin size used to reduce the data was not specified." Further, "the system used to determine the maximum slope angle was not specified," which is critical because an assessment of the shelf slope angle is part of the route selection criteria.

There was no mention of the range vs. altitude for side scan data collection nor discussion of the method "utilized to determine the position of the side scan system." Also, the method of documenting the [tow]fish position when its "distance from the GPS antennae changed" was not explained.

Many profiling systems were utilized, but the deployment techniques and computer operations (e.g., "real time collection, data archival…, and processing" and concurrent operation) were not explained.

The variability in line spacing for survey coverage was questioned. Specifically, the information used to determine the spacing. The speed of the survey vessel "during data acquisition is critical to the data quality." The vessel speed was left unstated.

Finally, software issues were addressed. The usefulness of the CRA-NW HP navigation software was not described. Also, The DF-1000 software used in data acquisition was not specified.

Data analysis

The QA/QC procedures were implemented but the "methods used to edit the data were not described." The reviewer commented on several procedures, particularly 'editing of the trackline data and correcting for position errors.' A station used for "RTCM-104 correctors" was not mentioned specifically, and the reviewer asked if the "horizontal and vertical accuracy objectives [were] published in the original survey specifications." A method outlining accurate position checks, as well as several benefits, was also discussed. Finally, an explanation of the system used to track the [tow]fish, cable lengths, and positioning should have been provided.

Results

Table 1 should have documented any evidence of potential submarine slides (e.g., sites 1 and 8 following the 2001 Nisqually earthquake). The reviewer indicated Figures 1-7 failed to reveal genuine seismic data. "The line drawing interpretations are cursory" (i.e., 'interpreted sketches'), thus difficult to distinguish if changes in slope were real or an "artifact of the cartographer." A set of interpreted and non- interpreted cross sections should be produced such that "another geologist could concur with the published interpretation." Also, seismic data would be better illustrated if Figures 1-7 were presented similar to Figure 2 in the phase 3 document *Conveyance System Interim Conceptual Geotechnical Assessment*. This figure presents the "geologic nature of the cross sections in a more appropriate manner."

Finally, the reviewer commented on the "Summary and Conclusions" section of the document. First, "there was no mention of research, technologies or criteria used to locate existing cables or cultural artifacts." A magnetometer was not part of the equipment list, but would be necessary to detect existing cables or cultural artifacts. Also, "sediment sampling would not be a good indicator of slope failure." Aside from the distorted samples and "mask[ed] in-situ stratigraphic patterns," coring might not detect "distortion in the upper strata that suggests failure." Lastly, a video survey would prove beneficial to other data sets when "determining the recent history of slope failure."

Document 1: *Marine Geophysical Investigation: Marine Outfall Siting Study.*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Report Reviewed
Marine Geophysical Investigation March 2001

February 20, 2003

Douglas R. Levin, Ph.D.
Geologist for Marine Outfall Siting Study (MOSS) Peer Review
BrightWater Marine Outfall Siting Study

General Comments

This evaluation is offered in the spirit in which it was assigned to the Puget Sound Marine Outfall – Formal Peer Review Panel. The comments are offered without the benefit of seeing the specifications requested of Golder and Parametrix prior to conducting the Marine Geophysical Investigation (March 2001).

Overall, it appears that an excellent data set was collected and used to answer the DEQ's posed by the King County Department of Natural Resources. In my opinion, the report prepared by Golder Associates and Parametrix was not commensurate with the amount of field data that was collected. The report prepared was more along the lines of an operations review than a technical treatise of the geology and geophysics of the candidate outfall corridors. The report was deficient in its description of QA/QC procedures, lacked the specifics for data gathering, and could have benefited from a strong literature and "previous work done" section. The "data interpretation" report section has been limited to a single paragraph and brief table of site characteristics. The data interpretation does not include enough text or figures to illustrate the pros and cons of each site. It was not clear who outside of the Parametrix/Golder team was assigned to determine the acceptability of data quality for the geophysical program.

1. Were the studies designed appropriately, with sufficient data to satisfy the objective(s)?

The equipment used to collect the data was appropriate. Data products created from the gathered data were not included in the report. Conclusions and analysis were made without detailed graphic support. It appears that the field data gathered for the analysis is sufficient to allow the program objectives to be met. The consulting group that gathered the data was satisfied that the field program was sufficient to meet the stated objectives.

2. Is the science sufficient behind the conclusions in each report?

"Based on considerable experience in conducting marine geophysical surveys in Puget Sound a line spacing of 200 to 400 feet seemed a reasonable balance between acquiring sufficient data to identify potential pipeline corridors". (email from Golder Associates)

--- The "experience" factor in this statement, it is not an acceptable substitute for a concise scientific-based determination for program design. Justification for the line spacing should be based on expected scales of lateral facies changes and tied to the objective of the program.

--- Is there a requirement that a Licensed Geologist be responsible for the geologic conclusions presented by this work? According to The Department of Licensing in Washington State, Effective July 1, 2002, people practicing geology or advertising geologist services in Washington are required to be licensed by the Department of Licensing. This includes geologists working for businesses, state and local governments, non-profit organizations, or those who are self-employed.

" Of primary importance was the location of low angle slopes, areas without existing slope failures, and areas that did not appear to have high-risk for potential slope failure (for instance, thick deposits of fine-grained sediment on steep slopes)". (email from Golder Associates)

--- Although thick deposits of fine-grained sediments on steep slopes may fail, an oversteep slope may not be required. Pulsed compressive and tensional forces imparted on sediments by waves on less steep slopes may cause liquefaction and failure (Kamphus, 1990, Sunamura, T., 1977). Further, fine-grained, cohesive sediments have higher angles of repose (angles of failure) and will fail more suddenly and catastrophically than non-cohesive sands. Although this might be more applicable to landslides, Watters, et al, (1996) study of Seismic Landslides in Puget Sound showed that smaller slides were evident north of Seattle "where the cohesionless Esperance Sand overlies the cohesive Lawton Clay. On submarine slopes, if unconsolidated sands lie over a clay shelf, it may be easier to move downslope by increasing pore pressure by "wave pumping."

---

3. Was sampling sufficient in all cases?

See item 2.

4. Were the correct parameters included?

On p. 9 of the Geophysical Report "The result of this lengthy analysis and evaluation process was the identification of eight sites that at present meet the geophysical/engineering DEQ's for placement of a pipeline and diffuser."

If the objectives were to satisfy questions within the Level One Detailed Evaluation Questions then they have been considered.

The question becomes what was the rationale for the selection of study within the DEQ?

BrightWater Marine Outfall Siting Study
Level One Detailed Evaluation Questions – March 2001

It appears that the Geophysical Report addresses the Level One DEQ's directly. If they were the target of the objectives then they have a direct relationship to the scientific merit of the Siting Study.

Engineering: Section 4.0, p. 7, 8

The engineering section of the Geophysical Report states that " extensive and detailed survey information will be used to address all of the technical DEQs. In areas not covered during the MOSS project survey, NOAA navigational charts will be used."

----Although some geologic information can be garnered from NOAA charts, they are not intended to be used for Engineering purposes.

4.1 Submarine Slides

According to the Level One DEQ's the correct parameters were considered. The scientific/engineering rationale to discount a route based on presence/absence of slope instabilities within 300m is not apparent.

4.2 Bathymetry

"Unacceptable bathymetry is a pipeline slope greater than 20 degrees or diffuser location slope greater than 2 degrees".

There is no cited engineering rationale for these criteria.

5. Was relevant data considered and used appropriately?

Other than the considerable reputation of the firm that conducted the geophysical investigation, there is no basis for determining whether relevant data was used appropriately.

6. Was something completely missed?

Review the following for additional and more detailed comments.

Brightwater Marine Outfall Siting Study
Marine Geophysical Investigation, March 2001
Golder Associates & Parametrix, Inc.

Report Comments:

1.0 Introduction

"The overall objective of the geophysical survey was to characterize the surficial geology and subsurface geology relative to the outfall siting."

A. Identify a number of alternative corridors, or sites, for the marine outfall, having gradual slopes and consistent and regular contours.

--- Specify the criteria & justification for these identifications. It is assumed these were taken from the DEQ.

B. Locate relatively flat zones for placement of a diffuser.

--- Quantify relatively flat, the slope of 2 degrees was stated in the DEQ.

C. Characterize the lateral and vertical extent of the surficial sediment and subsurface geology.

---- With what objective?

D. Identify possible surficial and subsurface geohazards, or geologi conditions, that might impact the construction or operation of the outfall or diffuser.

2.0 Regional and Geologic Setting, p.3

A. There were no scientific references cited in the regional and geologic settings, although there was a reasonable and more detailed treatise of this material in the "….Conveyance System Interim Concept Geotechnical Assessment".

B. "In some places, the unconsolidated post-glacial sediment fill, as well as the older glacial deposits along the margins of the basin have been involved in slope failures and submarine landslides".

There were no scientific or technical references sited for these incidents. Were these failures considered within the project scope and specifications? See the discussion to question 2 in the preamble (above).

3.0 Methodology, Instrumentation, and Field Operations

p.4 "During most of the investigation, the three primary acoustic systems; the echosounder, subbottom profiler, and seismic reflection system; were operated simultaneously".

It is not uncommon to run the side scan sonar and multibeam with single beam echosounders, sub bottom profilers, and boomer systems simultaneously.

p.4 "The side scan sonar was run with the multibeam echosounder and high- energy seismic refelction system was run on selected transects parallel to the slope".

It is assumed that parallel to slope means perpendicular to the contours or along the dip.

3.2 Navigation

CRA-NW HP nav software

The utility of this software has not been described. How does it compare to standard navigation software such as Hypack, and/or Winfrog?

"In addition, this system made it relatively easy to relocate the vessel in areas of interest and run additional lines". This capability was used on a number of occasions when preliminary analysis of the data identified areas of concern?"

The caveat that "this capability was used on a number of occasions" has not been detailed in the report. In which corridors were "areas of interest" defined and where were additional lines added?

3.3 Instrumentation

3.3.1 Precision Echosounder

An Odom Echotrack was used to acquire "Precision bathymetric data". The transducer used during this operation was not specified, nor was it described how this data was used.

The Reson Model 9001 is the correct system to be used for the study area's depth range. When using the Reson Model 9001 multibeam system the bin size used to reduce the data was not specified.

The system used to determine the maximum slope angle was not specified. This is critical. If the center beam of the Reson cannot be isolated, then the maximum slopes of a mapped area may not be accurately assessed using this system. On smaller scale sea floor slopes, for example, those found on the slip face of bedforms, true seafloor slopes are better measured using single beam data. In multibeam systems if the data is averaged within a “square” bin size, the actual slopes will be lessened by depth averaging.

3.3.2 Side Scan Sonar

Seeing that a DF-1000 was used, what software was the data acquired with? It does not appear that both the 100 and 500 kHz frequency data was collected at the same time, although that is within its capability. Was the side scan data played back and a mosaic created using software such as Triton-Isis or ChesapeakeTech and translated to an ArcView GIS data base?

p.5 “Depending on the depth of water, and the frequency of the transducer selected, the graphical display was set for a swath width that varied from 450 to 600 feet. (70m to 91m)”

Depth of water is not a consideration for side scan sonar frequency selection. Depth is a consideration for determining the depth capabilities of a side scan sonar system.

100m is the nominal range for acquiring 100 kHz side scan sonar data and the outside maximum for 500 kHz. 70m is an acceptable for range for either frequency. 100 kHz is a good frequency for discerning most bottom types. 500 kHz (closer to 400 in actuality) is thought to be better for detail work (high resolution). The 100 kHz frequency will see through silt dustings where the higher frequency system might not.

Depth of water and side scan considerations can come into play if the fish altitude is small (<10% of the fish range). In this case, the frequency does not change, but the angle of the transducers can be adjusted from the 20 degree factory setting to 10 degree for shallow water and acoustic echo amplification of low, proud, targets.

There was no range of depth mentioned in the report that the side scan data was collected in, or any mention of the system utilized to determine the position of the side scan system. If, as mentioned earlier, that the side scan was run on transects parallel to slope then cable would have been paid out or recovered during the data run. It has not been stated how the position of the fish was accounted for as its distance from the GPS antennae changed.

3.3.3 Sub Bottom Profiler (SBP)

An impressive array of sub bottom profiling systems was used for this program. The methods of their deployment, whether computers were used for real time collection, data archival (as opposed to DAT tapes), and processing and whether they were run concurrently was not described. Was Delph Seismic or an equivalent used to process the data?

3.4 Survey Coverage

Interval between transects varied between 200 and 400 feet.

Why the variability in line spacing?

Line spacing is predicated on expected lateral facies changes. What information was utilized to determine the line spacing, For example, was Mosher, et al, 2001, Onshore and offshore geohazards of the Fraser River Delta, or similar reference type considered?

"Slope instability (landslides, sloughing, etc.) will be classified as present within 300m of the proposed pipeline route and diffuser location or absent from the surrounding 300m area. This information will be obtained from the MOSS geophysical investigations and NOAA Navigational charts."

What was the scientific resource used to create this 300m specification. How would NOAA Navigational charts be used to identify geotechnical/slope instabilities?

"The quality of the data ranged from very good to excellent. The poorest quality data resulted during the late afternoons when wave conditions increased or because of acoustic noise from passing survey vessels. Both events occurred for periods of less than 1 hour each day."

In the first sentence data is qualified as very good to excellent. Does this mean that the poorest quality data was "very good"? Who, outside of the field group (Golder), was responsible for determining the acceptable quality of the geophysical data?

"…or because of acoustic noise from passing survey vessels". Was there another survey vessel in the area? If so, what was it doing?

Vessel speed maintained during data acquisition is critical to the data quality. This aspect of the survey was not mentioned in this report. The DF-1000 collects the best quality side scan data at speeds of less than 5 knots, the geophysical data would also be optimally collected at slower speeds.

4.0 Data Analysis and Selection Criteria

QA/QC procedures – "The following QA/QC procedures were undertaken prior to analysis and interpretation of the data.

What was done, i.e. Editing of trackline data, and correcting for position errors, was a step that was completed, the procedures/methods used to edit the data were not described.

---What were the type, range of and source of error(s)?
---What criteria were used to determine whether data was accepted or rejected?
---Was there post processing of the DGPS data to improve accuracy?
This QA/QC procedure should be part of the report/appendices.

Editing of the trackline data and correcting for position errors.

Puget sound apparently has excellent correctors for vessel positioning. There is no specific mention of station used for RTCM-104 correctors, although the Edmonds tidal benchmark ID 9447427 would have been a candidate. Were horizontal and vertical accuracy objectives published in the original survey specification?

Depending on the program objectives, the least confident position check involves checking a receiver position against the position of a benchmark and then installing that receiver on a vessel. A more accurate methodology would be to have the receiver installed on the ship that will be doing the ship and then measuring its position (antennae) relative to the benchmark, back sighting and recording measurements every minute for an hour. This gives the antennae position measurement on the ship a set of 60 known data points. This serves to verify the installed receiver position against the known benchmark. Furthermore, it allows a data set to be generated to verify whether the DGPS station on board is functioning properly in respect to data collected there after. It also allows for a post survey check to verify that the system collected accurate position data, within specified accuracies, for the program duration.

Second, there is no mention, in the report as to how the tow fish was treated with respect to antennae offsets. In evaluating the various water depths that were surveyed using the side scan system, how was layback and changing cable lengths treated in determining target position in the records? If a USBL (Ultra Short Base Line) system, was used to track the fish, then the position of the fish relative to an acoustic beacon, run at each of the cardinal headings would be preferred. If this was not used, manual entering of the cable length and the procedures used to determine the fish position requires explanation.

Editing of the bathymetric data, correcting for sound velocity, and for changes in elevation data due to tides.

Again, the process did occur, the procedure has not been explained.

Plotting the bathymetric soundings and checking for errors in depths at line crossings.

What was the margin of error for acceptance? Who determined these criteria?

Reprocessing and replaying of selected side scan sonar, sub bottom profiler and seismic reflection data.

What system was used to process the SSS and SBP data? Who was responsible for this?

"Upon completion of these QA/QC steps a set of geophysical criteria were used for identifying regions or zones that would possibly be acceptable for routing a pipeline and locating a diffuser. "

Site selection considerations, referred to as "detailed evaluation questions" (DEQ's) were developed for each aspect of the MOSS project to ensure that sufficient data were available to support policy criteria approved by the Metropolitan King County Council. These DEQs were developed at a number of meetings with the King County marine outfall siting team.

Who was responsible for determining these criteria and what scientific literature/work was considered to support the decisions?

In reviewing Level One Detailed Evaluation Questions there were no geologic references cited that might support the specified route criteria. References addressing geologic concerns for Phase 2 Detailed Evaluation Questions, Marine Outfall Siting Study were not listed.

The DEQs addressed bathymetric conditions, potential geohazards such as submarine slides, faults, and sediment type. Using these DEQs, a number of sites were identified that are potentially acceptable pipeline corridors or diffuser sites. In summary, the engineering/geophysical deq's considered the following conditions as being potentially acceptable.

- **Gradual slopes of less than 20 (angle of repose?)**

--- What is the angle of repose for the material/strata in this area?

- **Diffuser sites with 2 degree slope in water depth > 100ft.**

---- What criteria were used to make 2 degrees the cutoff?

- **No evidence of recent slides, slumping, subsidence, shallow faulting**

---- Define recent

5.0 Results of Geophysical Data Interpretation

Table 1, p. 11. In this table the Geophysics/Geology interpretation for Site 1 states that "no faulting or slides" are noted. In Site 2 the Geophysics/Geology states that "No slump features or faults" exist. Does this mean that slump features exist in Site 1 and slide features exist in Site 2? In addition, since there is no mention of slumps, slides, or faults in Sites 2 – 8B is it implicitly stated that they are absent? Does the non-inclusion of the statement "No slumping, faulting, or slides" in the table for sites 3-8b imply that instabilities are present? In the Geotechnical Assessment of May 2002 slope instabilities were mentioned in Site 6. This was not mentioned in this (albeit earlier) investigation. It is also important to note that evidence of (possible) submarine slides were cited at sites 1 and 8 following the Nisqually earthquake.

Figures 1A to 8B do not show real seismic data along these routes. The line drawing interpretations are cursory ("interpreted sketches", p.10) and difficult to garner real geologic information from. It is difficult to discern whether changes in slope illustrated in these figures are actual or an artifact of the cartographer (see following interpretations). A better presentation would include a series of uninterpreted and interpreted cross sections so that another geologist could concur with the published interpretation.

For example, Figure 2, Reflection Profile Example published in Brightwater Marine Outfall Conveyence System Interim Conceptual Geotechnical Assessment, shows what real seismic data looks like. This type of data product with the accompanying interpretation. The Interpreted geophysical and geologic profiles published in the "Conveyence System Interim Conceptual Geotechnical Assessment" illustrate the geologic nature of the cross sections in a more appropriate manner.

Figure 1 (The figures did not have page numbers associated with them): The sediment/water interface appears to have a slope change/inflection at around 350'. There is also a "toe" at around the 500' level that. This type of slope change could be interpreted as a pressure ridge of a rotating slump block.

Figure 2: There is a notable inflection at the slope base, around 400', that might indicate potential for slope failure. The reflective surfaces drawn into the cross section suggest either truncation by erosion or possible previous slope failure.

Figure 3: The chaotic reflectors and change in slope and sediment type at 400' suggest that slope failure has occurred. The profile suggests evidence of a rotated slump block.

Figure 4: no comment

Figure 5: What is the provenance of the fine to medium grain sands at the base of the slope? The lack of sand in the mid range of the slope is conspicuous by its absence. Did it come downslope from the sands above 120', suggesting some failure in the unconsolidated sediments?

Figure 6: Similar to 5, is the talus at the base of the slope derived from the surficial unconsolidated materials indicated above 100'?

Figure 7a-d: See Figure 5 and 6.

Figure 8 a-b: See Figures 5,6,7

6.0 Summary and Conclusions

"The bathymetric and geophysical data were used to map the water depth, characterize the seabed sediment, identify possible geohazards such as submarine slide, faulting, zones of subsidence, and locate existing cables and other cultural artifacts"

--- There was no mention of research, technologies or criteria used to locate existing cables or cultural artifacts. A magnetometer was absent from the equipment list that would be necessary to satisfy this objective.

"It is recommended that…. sediment sampling and a video survey be performed along the proposed route…"

--- Sediment sampling would not be a good indicator of slope failure. Coring might or might not show distortion in the upper strata that suggests failure. Also, the coring would distort the sample and mask in-situ stratigraphic patterns. A video survey would assist the other data sets in determining the recent history of slope failure.

7.0 Addendum: Post Earthquake Survey

No comments

References Used In This Report

Kamphus, JW, 1990, Influence of sand or gravel on the erosion of cohesive sediment: Jour. Hydraulic Res., v28, p.43-53

Sunamura, T., 1977, A relationship between wave-induced cliff erosion and erosive forces of waves: Jour. of Geology, v.85, p. 613-618.

Watters, RJ, MJ Grass, CF Prunier, 1996, Seismic landslides in Puget Sound (SLIPS) III: Controls on stability: http://www.seismo.unr.edu/ftp/pub/papers/96agu/watters.txt

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

Respondent: Dick Sylwester, Senior Geophysicist, Golder Associates Inc.

From the full text review- referring to the General Comments section:

1. The question becomes what was the rationale for the selection of study within the DEQ?

From the full text review- referring to Section 1.0, Introduction:

1. Characterize the lateral and vertical extent of the surficial sediment and subsurface geology. Question: With what objective?

> *RESPONSE: To help in understanding the regional site stratigraphy and geology and to assist in providing qualitative engineering characteristics of the seabed for the purpose of identifying potential preferred and workable outfall zone and routes; to assist in selecting sites for geotechnical borings.*

From the full text review- referring to Section 2.0, Regional and Geological Setting:

1. Regarding this statement from the document: "In some places, the unconsolidated post-glacial sediment fill, as well as the older glacial deposits along the margins of the basin have been involved in slope failures and submarine landslides."

Question: There were no scientific or technical references sited for these incidents. Were these failures considered within the project scope and specifications?

> *RESPONSE: Not sure what the question is asking. One purpose of the investigation was to identify slope failures and evidence of submarine slides.*

From the full text review- referring to Section 3.2, Navigation:

1. The utility of this software [CRA-NW HP] has not been described. How does it compare to standard navigation software such as Hypack, and/or Winfrog?

> *RESPONSE: We would not normally compare the navigation software (or any other systems used) to another system i.e. Hypack vs. Winfrog, Winfrog vs. CRA etc. For the reviewer interest we have added comments from Craig Keener, the project navigator who is a registered Hydrographic Surveyor and the principal developer of the navigation system. Mr. Keener has 25 years of programming and hydrographic surveying experience.*
>
> *COMMENTS FROM HYDROGRAPHER: Hypack is only a standard for COE/NOAA type projects and Winfrog is a quasi-standard for rig move and oil patch related projects. We (CRA-NW) own and use both systems in limited areas. However, to fully provide the*

highest level of real-time navigation to our clients for all arenas of high precision navigation we continuously develop our own navigation software.

The software was initially developed for the oil/seismic type of projects beginning in 1982. The code was later modified to perform precision hydrographic surveys for COE/NOAA type projects. CRA, Inc. and now CRA-NW have been developing their own software for over 20 yrs, which was before the PC was able to perform real-time data acquisition. This development and operations was done on the Hewlett-Packard small desktop computers (9825/200/300 series computers). The majority of that proven code has now been converted into a 'Windows' based navigation program called CatNav, Continuously Automated Tracking Navigation.

The basis of this navigation software is to time tag all input data as accurate as possible when the data arrives at the input ports. Any known latency is applied for each device. This data is then stored when directed by the operator. In addition the data is sampled and evaluated for obvious errors, ie zero depths, and the operator is alerted. The position data is converted to the local datum, filtered, and analyzed for any large discrepancies. Then the normal helmsman information is displayed, ie. off track, down track, speed, heading, ship shape, etc.

2. The caveat that "this capability was used on a number of occasions" has not been detailed in the report. In which corridors were "areas of interest" defined and where were additional lines added?

RESPONSE: These "areas of interest" were those areas located in-between transects where the subsurface geology on adjacent lines did not seem to "fit" or it appeared that additional data should be obtained because of potential geohazards. It was a qualitative call often made in the field or following preliminary analysis of the data after several days of field work. Approximately 10 to 15 transects or partial transects were run for this purpose.

From the full text review- referring to Section 3.3.2, Side Scan Sonar:

1. Seeing that a DF-1000 was used, what software was the data acquired with? Was the side scan data played back and a mosaic created using software such as Triton-Isis or ChesapeakeTech and translated to an ArcView GIS data base?

RESPONSE: The data were acquired on a Sony DAT; this system does not require software. The side scan data were not played back on Triton Isis or ChesapeakeTech to produce a mosaic; this capability was not specified in the proposal. Some reprocessing of the data from the Sony DAT tapes was done using the GeoAcoustic GeoPRO and the data were then printed on the EPC 1086-500 and viewed on an LCD monitor.

From the full text review- referring to Section 3.3.3, Sub Bottom Profiler:

1. Was Delph Seismic or an equivalent used to process the data?

RESPONSE: Delph Seismic was not used to reprocess the data. It was reprocessed with the GeoAcoustic Model 5210 Amplifier/Filter.

From the full text review- referring to Section 3.4, Survey Coverage:

1. Why the variability in line spacing? [between 200 and 400 feet].

RESPONSE: As previously stated (Jan 23, 2003 memo to Dan Averill) the selection of the line spacing was based on experience in conducting marine geophysical investigations in Puget Sound (70 marine surveys including 10 for marine outfalls), information from the NOAA bathymetric charts and data from other surveys. For example areas of apparent slope failures, or steep canyons, as interpreted from the contour maps, received less coverage (wider line spacing) than those areas that did not have these apparent limitations.

2. What information was utilized to determine the line spacing? For example, was Mosher, et al, 2001, onshore and offshore geohazards of the Fraser River Delta, or similar reference type considered?

RESPONSE: Information from knowledge gained in planning and conducting offshore marine geophysical investigations for 35 years. Reference material included some 50 documents on marine geophysics including 8 reports from other outfall investigations in Puget Sound, USGS open file reports, Univ. of WA papers and thesis and published papers (e.g. Marine geophysical evidence of recent submarine slope failures in Puget Sound, Washington; Outfall relocation study in Commencement Bay, Washington; Submarine Flow Slides in Puget Sound, etc.)

3. What was the scientific resource used to create this 300m specification. How would NOAA Navigational charts be used to identify geotechnical/slope instabilities?

RESPONSE: There was no scientific resource to suggest this specification-it was based on the experience of pipeline and outfall engineers on the PMX team.

Regarding this statement from the document: “The quality of the data ranged from very good to excellent. The poorest quality data resulted during the late afternoons when wave conditions increased or because of acoustic noise from passing survey vessels. Both events occurred for periods of less than 1 hour each day”

4. In the first sentence data is qualified as very good to excellent. Does this mean that the poorest quality data was “very good”?

RESPONSE: The poorest quality data were very good; in the event of poor or unacceptable data the transect was rerun or the survey was delayed until sea conditions improved or the survey was terminated for the day if poor sea conditions persisted.

5. Who, outside of the field group (Golder), was responsible for determining the acceptable quality of the geophysical data?

The survey program and data quality was discussed and reviewed by Dr. Mark Holmes at the Department of Oceanography, Univ. of WA. Dr. Holmes has worked in the vicinity of this site, as well as throughout Puget Sound since 1965. The acceptable quality was the responsibility of the Golder Senior Marine Geophysicist.

6. Was there another survey vessel in the area? If so, what was it doing?

RESPONSE: No. The statement should have referred to other vessels (pleasure crafts, ferries, commercial shipping) in the area.

<u>From the full text review- referring to Section 4.0, Data Analysis and Selection Criteria:</u>

1. What were the type, range of and source of error(s)?

RESPONSE: Types of potential errors included errors in position and depth. The range of position errors was less than +/- 6 feet. The range of error in depth is estimated to be less than +/- 1% of water depth plus .5 foot.

2. What criteria was used to determine whether data was accepted or rejected?

RESPONSE: Verfication of the DGPS data was accomplished by using two independent RTCM-104 correctors at a common point (Edmonds marine dock) and comparing the position using the same receiver. In addition during the survey the PDOPs was always at 7 or lower. The ACOE Navistar Global Positioning Manual EM1110-1-1003 Table 8.1 GPS survey Design, Geometry, Connections and Observing Criteria was used as reference.

3. Was there post processing of the DGPS data to improve accuracy?

RESPONSE: No, not considered necessary.

4. Were horizontal and vertical accuracy objectives published in the original survey specification?

RESPONSE: No

5. In evaluating the various water depths that were surveyed using the side scan system, how was layback and changing cable lengths treated in determining target position in the records?

RESPONSE: The side scan sonar was used in relatively shallow water (out to a depth of approximately 150 feet). The cable out, water depth, and height of fish above the bottom were used to make any calculations for determining layback and target position.

6. Regarding "plotting the bathymetric soundings and checking for errors in depths at line crossings:" What was the margin of error for acceptance? Who determined these criteria?

> *RESPONSE: The margin of error for acceptance of data at the crossings +/- 3 feet to +/- 6 feet depending on the water depth. Golder/CRA-Hydrographic recommended this criterion for this investigation guided by ACOE specifications for hydrographic surveying.*

7. What system was used to process the SSS and SBP data? Who was responsible for this?

> *RESPONSE: When deemed necessary the side scan sonar data were reprocessed with the GeoAcoustic GeoPRO. The SBP data were reprocessed with the Datasonic Model 1200 SBP amplifier/filter and/or GeoAcoustic processing amplifier-filter. Golder was responsible for all reprocessing of data.*

8. Regarding DEQ's: Who was responsible for determining these criteria and what scientific literature/work was considered to support the decisions?

> *RESPONSE: The criteria were developed during a number of meetings with the King County and PMX team members. The decisions are based on the collective experience of the PMX and King County team members who have worked on other outfall installations in Puget Sound and elsewhere.*

9. What is the angle of repose for the material/strata in this area?

> *RESPONSE: It would depend on the material and the strata. The angle of repose for the fine to medium-grained sediment, based on diver observations at Edmonds near the Unocal Dock, was 30 to 35 degrees (friction angle of 35 to 40 degrees).*

10. What criteria were used to make 2 degrees the cutoff?

> *RESPONSE: It was based on the experience of the engineers on the PMX team.*

<u>From the full text review- referring to Section 5.0, Results of Geophysical Data Interpretation:</u>

In Table 1 the Geophysics/Geology interpretation for Site 1 states that "no faulting or slides" are noted. In Site 2 the Geophysics/Geology states that "No slump features or faults" exist.

1. Does this mean that slump features exist in Site 1 and slide features exist in Site 2?

> *RESPONSE: No; should be restated to indicate that no faults, slides or slump features were noted at either site.*

2. In addition, since there is no mention of slumps, slides, or faults in Sites 2 – 8B is it implicitly stated that they are absent?

RESPONSE: No. Table 1 located In the Brightwater Conveyance System Interim Conceptual Geotechnical Assessment, May 2002 states that Zone 6 showed evidence of submarine slope failure. This was inadvertently left out of Table 1 in the report reviewed.

3. Does the non-inclusion of the statement "No slumping, faulting, or slides" in the table for sites 3-8b imply that instabilities are present?

RESPONSE: No. Unstable conditions can exist or be present but not be evident on geophysical data.

4. Figure 5: What is the provenance of the fine to medium grain sands at the base of the slope? Did it come downslope from the sands above 120', suggesting some failure in the unconsolidated sediments?

RESPONSE: Bluff erosion; longshore transport and down slope movement of unconsolidated sediment is an ongoing process in Puget Sound and is the source of material on the slope. On occasions some of these deposits probably undergo some type of failure mode i.e. submarine slide.

5. Figure 6: Similar to 5, is the talus at the base of the slope derived from the surficial unconsolidated materials indicated above 100'?

RESPONSE: There is no talus at the base of the slope in Puget Sound. On Figure 6 fine to medium-grained sediment are located at the base of the slope and these most likely are derived from unconsolidated material upslope.

Document 2: *Brightwater Marine Outfall Conveyance System Interim Conceptual Geotechnical Assessment. May 2002*

Coordinator's Summary

General comments

The individual peer reviewer examined the entire technical document and provided comments throughout. It appeared sufficient data were available to satisfy the objectives, though some of the available data were not used. For example, "side scan sonar data [did not appear to have been] used in conjunction with the geophysical interpretations along the profile routes." A "very good treatise" of seismicity was prepared but a reference page was not included. Further, "methodologies of measuring the slope" were not discussed.

A more comprehensive document would have included "details for collection, editing, and analysis of data." The document "lack[ed] sufficient detail in text and figure to determine how the conclusions were" reached. Based on the Level One DEQ's, the "correct parameters were considered." However, the "scientific/engineering rationale to discount a route based on…slope instabilities within 300 m [was] not apparent." Moreover, there was "no cited engineering rationale" for the "unacceptable bathymetry" criteria listed in Section 4.2. Lastly, the use of geophysics "was an excellent investment" but "the rationale for using one core along a four-thousand foot profile was not offered."

Next, the reviewer addressed each Zone, presented initially in the Executive Summary. Generally, "contour attributes or geologic features depicted in the accompanying figures" were not addressed in the Executive Summary.

Zone 5: The description did not "detail the increase in slope between 2400' and 3000' on the profile." Also, "it should be certain that the maximum slopes encountered within the proposed route be accurately calculated." The "submarine/headwall erosional feature" near the A-A' centerline was not mentioned.

Geologic Profile for Zone 6 (sheet 2): The reviewer noted a "rotated slump block headwall [was] located within the 300' criteria stated in the DEQ as acceptable from A-A'." Also observed within this 300' criterion was an "excessive side slope," with "curiously symmetrical" contours that might be an "artifact of multi-beam processing." This should be re-examined.

Zone 7N Shallow: The figure for this zone indicated "a channel feature that has been buried…[thus] if tunneling was considered, this would cause this site to be eliminated from consideration."

Geologic Profile for Zone 7N (sheet 3): The contours indicated a channel incision, but "might be an artifact of the data that requires cleaning." "Data cleaning, or filtering, should be exercised in the shallow shelf areas where contours cross on several occasions."

Geologic Profile for Zone 7S (sheet 4): Probable "artifacts of the multibeam data" appeared in the shallow contours and should be re-evaluated. Also, "erratic and symmetrical contours below 300 ft" should be examined.

In the Geophysics section (3.2), data such as terrestrial investigations and "seismic and electrical resistivity imaging profile" were not presented in any tabular or graphical form "to indicate where it was collected." The description of the methods and instrumentation in Appendix A was not detailed, and "how the system was applied, positioned, and operated [was] not described." Further, figures were absent that would "show how the data [was] represented for interpretation." Finally, reference of "parallel to slope" and "perpendicular to the shoreline" should be clearly distinguished and used consistently throughout the document.

In Section 3.3, there was "no discussion, or rationale, for the selection of the boring sites [or boring intervals for geotechnical sampling and testing]." The "peak ground acceleration" specified in the Seismic Setting section offered "no means…to determine whether the [peak ground acceleration] suggest[ed] this is a high, medium, or low risk area." The description of geology for bottom and subbottom conditions in Zone 5 was "significantly different" than the description offered in the Geophysical Investigation. Finally, the reviewer was unclear whether sufficient geophysical data were collected in the onshore area of Zone 6 "to allow a cross-section to be constructed."

Figures

Figure 2 was "an excellent example of the type of data that could be presented for each site." Figure 3, however, provided "no scientific value" because it presented "no land base for reference…no vertical scale, no vertical exaggeration…and no compass rose for orientation."

Appendix A: Geophysical Methods and Instrumentation

Information was not provided in Section A.1, or the previous Geophysical Investigation report, "to determine what the backup equipment consisted of and what tests were performed." Procedures in the Navigation section described relocating and running additional lines "when preliminary analysis of the data identified areas of concerns." The reviewer stated "an explanation or further description of where this might have been applied could be offered." Also, "vertical control maintained by the tug's fathometer and conventional sounding line [was] not…detailed." Finally, "side scan sonar was notably absent from this program," and data collected during the Geophysical program was not cross-referenced to "corroborate conditions" (e.g., the description of Zone 5 bottom and subbottom conditions mentioned earlier).

Quality Assurance/Quality Control

The document did not contain information that would "show how the data were handled and processed, what problems were presented, and how quality control procedures were applied."

Document 2: *Brightwater Marine Outfall Conveyance System Interim Conceptual Geotechnical Assessment. May 2002*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Report Reviewed
Brightwater Marine Outfall Conveyance System Interim Conceptual Geotechnical Assessment
February 20, 2003

Douglas R. Levin, Ph.D.
Geologist for Marine Outfall Siting Study (MOSS) Peer Review
BrightWater Marine Outfall Siting Study

Summary

This evaluation is offered in the spirit in which it was assigned to the Puget Sound Marine Outfall – Formal Peer Review Panel. The comments are offered without the benefit of seeing the specifications requested of Golder and Parametrix prior to conducting the Marine Outfall Conveyence System. As stated in 1.2 Limitations (Under 1,0 Introduction) "….these results are only suitable for conceptual engineering and environmental impact assessment…not sufficient for design". Aside from the scientific merit of the report, the document could have been edited a little more thoroughly.

1. Were the studies designed appropriately, with sufficient data to satisfy the objective(s)?

There appears to be sufficient data to satisfy the objectives. However, it does not appear that all of the available data was used to arrive at the objectives. For example, it does not appear that side scan sonar data was used in conjunction with the geophysical interpretations along the profile routes. In terms of seismicity, a very good treatise of the earth movement tendencies in the area was prepared, although a reference page for that report section has not been included.

Since slope is a critical issue in the siting of the outfall, there was no discussion as to the methodologies of measuring the slope. Was the slope measured from the single beam echosounder information? Or is it possible to isolate the center beam of the Reson unit (I didn't think so)? Or was the slope averaged from bin averaged slopes created by the Reson system?

2. Is the science sufficient behind the conclusions in each report?

The science applied to the objectives is probably sufficient. If I did not know of the high reputation of the firm and Chief Geologist that conducted and prepared the report I would suggest an independent review of the raw data. A more thorough report that contained the details for collection, editing, and analysis of the data would allay any reviewer's concerns. The report lacks sufficient detail in text and figure to determine how the conclusions were arrived at. If the figures have been plotted and presented in a full size format, i.e. C or D size plots the review might have been a little easier. As this reaches construction phase full size plots of the areas will need to be generated for proper post-processing analysis.

3. Was sampling sufficient in all cases?

The use of geophysics to characterize each potential site was an excellent investment. The rationale for using one core along a four-thousand foot profile was not offered, especially where abrupt facies changes are indicated in the interpreted geophysical/geophysical profile. The costs of coring in the open ocean are high, but once the rig is mobilized, the per-core costs are reduced. The information garnered from the sample can be a long-range cost saver. If the core site was selected after analysis of the geophysical data and further rationale, it is unclear. Further, boring BH-1A was taken nearly 300ft from the proposed CL, BH-2, BH-3, and BH-4 were within a reasonable distance of the CL.

4. Were the correct parameters included?

It is assumed that the Conveyence Investigation objective was to satisfy the DEQ's as described in Phase 2 Detailed Evaluation Questions Marine Outfall Siting Study (September 2001). Section 5.0 Conveyence Route DEQ's are identical to those posed in the Level One Detailed Evaluation Questions of March 2001.

BrightWater Marine Outfall Siting Study
Level One Detailed Evaluation Questions – March 2001

Engineering: Section 4.0, p. 7

"The extensive and detailed survey information will be used to address all of the technical DEQs. In areas not covered during the MOSS project survey, NOAA navigational charts will be used".

Although some geologic information can be garnered from NOAA charts, they are not intended to be used for Engineering purposes.

4.1 Submarine Slides

According to the Level One DEQ's the correct parameters were considered by the geotechnical/geophysical consultant. The scientific/engineering rationale to discount a route based on presence/absence of slope instabilities within 300m is not apparent.

4.2 Bathymetry

"Unacceptable bathymetry is a pipeline slope greater than 20 degrees or diffuser location slope greater than 2 degrees".

There is no cited engineering rationale for these criteria.

5. Was relevant data considered and used appropriately?

Other than the considerable reputation of the firm that conducted the geophysical investigation, there is no basis for determining whether relevant data was used appropriately.

6. Was something completely missed?

Review the following for additional and more detailed comments.

Brightwater Marine Outfall Conveyence System
Interim Conceptual Geotechnical Assessment
Golder Associates & Parametrix, Inc.
May 2002

Report Comments:

EXECUTIVE SUMMARY

In general, the executive summary of each zone does not address contour attributes or geologic features depicted in the accompanying figures. These comments/ additions meld the figures of the Profile sheets within each Zone. Perhaps this doesn't belong in the Executive Summary, but that's where the information was presented first.

"General comments for each Zone are presented below" p.1

Zone 5: The "Broad, very gentle shelf area in shallow water and a relatively uniform 8-degree slope dropping down into deeper water". This description does not detail the increase in slope between 2400' and 3000' on the profile, between 100 and 400 ft of water. It appears that average slope measurements are reported. It should be certain that the maximum slopes encountered within the proposed route be accurately calculated. Further, no mention was made of the submarine/headwall erosional feature located within 300 feet of the A-A' centerline at a water depth of ~450'. What is the prognosis of this slope failure migrating up dip in order to attain equilibrium?

Figure: Geologic Profile Zone 5 – Sheet 1: The profile depth marks, i.e. 1,000, 2,000, 3,000 do not line up with the bathymetric contours.

Zone 6: "Sediment appear unstable on mid and upper steep slope areas and evidence of submarine slide was identified."

Figure: Geologic Profile Zone 6 – Sheet 2: The rotated slump block headwall is located within the 300' criteria stated in the DEQ as acceptable from A-A'. Along the A-A' profile, the rise/run for the area between –100 and –150ft (50/113) calculates to a slope angle of approximately 22 degrees, when the information is pulled from this figure. To the north/upper part of the figure from the 3000' profile mark there is an excessive slope depicted in the contours. This excessive side slope is well within the 300' criteria for concern. However, the contours in the upper section of this figure are curiously symmetrical. This bathymetric information might be an artifact of multi-beam processing and should be re-examined. Especially in light of the flat topped ridge that is depicted to run landward at the 560ft contour. In the figure the core BH-1A has a label "Projected 330' South); Is the figure projected 330' south of its actual location?

Zone 7N Shallow: "300 feet offshore, the thick glacial/interglacial soils appear to have been eroded, leaving a channel or depression that is 500 to 1000 feet wide and 30 – 120 feet deep." The figure for Zone 7 does indicate a channel feature that has been buried. If tunneling was considered, this would cause this site to be eliminated from consideration (DEQ 5.4 in phase 2).

Figure: Geologic Profile Zone 7N – Sheet 3: The contours just north of the CL near BH-2 indicate a channel incision that shallows in the offshore direction. This might be an artifact of the data that requires “cleaning”. Data cleaning, or filtering, should be exercised in the shallow shelf area where contours cross on several occasions. The excessively steep slope at the northeast and northwest extremes of the figure also suggest the use of out of range data in this figure.

Zone 7S Shallow: “Alignment crosses an area underlain by 15’ of recent marine sediments and dredge spoils.” This wording is unique. Geologically, sediments normally overlay the previous unit. The wording can be interpreted as the materials being mixed, but likely passes zones of recent marine sediment lying adjacent to the dredge material. Further, “Localized zone of boulders at approximately 500 to 700 ft from the shoreline, located at a subsurface depth of 50 to 60’”. Did these boulders would show up on the seismic reflection data as hyperbole?

Figure: Geologic Profile Zone 7S – Sheet 4: The shallow contours (0 to –50) show probable artifacts of the multibeam data that should be re-evaluated. The erratic and symmetrical contours below 300 ft should also be examined for accuracy. The data artifacts located several hundred feet north of the CL should be clipped.

Zone 7S Deep: “Low gradient shelf approximately 1,000 feet wide”. There appears to be a submarine channel-like feature between –50 and –100 feet within 300 feet of the CL south of CL point 1000 ft.

1.0 Introduction

---- No comment

1.2 Limitations

---- No comment

2.0 Site and Project Description

---- No comment

3.0 Explorations

3.1 General

“Section 2.2 below only discusses the most recent geophysical investigations….” It is assumed that this is referring to 3.2, not 2.2, Geophysics. Although this is not a scientific flaw, the report should have undergone a more rigorous editorial review prior to submission.

3.2 Geophysics & Appendix A – Geophysical Methods and Instrumentation

“The offshore geophysical marine survey transects were **oriented perpendicular to the shoreline** from the 0-depth contour to the 100 ft contour (p.4). The interval between transects varied from 50 to 100 feet. A secondary set of transects ran **parallel to the slope**…”

---Referring to p.4 of the Marine Geophysical Investigation where the report states that the data was collected on select transects “parallel to the slope“What is the difference between parallel to the slope and perpendicular to the shoreline? “Parallel to the slope” can have two connotations, where parallel can be interpreted to mean parallel to strike or dip of the slope. The report should make these distinctions clear and then use them consistently.

Appendix A – Geophysical Methods and Instrumentation

The geophysical investigation for this study included: Precision echosounding, High resolution reflection profiling, electrical resistivity, and marine/seismic refraction.

A.1. Survey Vessel: “The backup navigation and geophysical instruments were also tested at this time”. No information has been included in this or the March 2001 geophysical report to determine what the backup equipment consisted of and what tests were performed.

Refer to the comments written for the Marine Geophysical Investigation for additional detail.

A.2. Navigation: “In addition, this system made it relatively easy to relocate the vessel in areas of interest and run additional lines. This capability was used on a number of occasions when preliminary analysis of the data identified areas of concerns”

---- This statement was also made in the Marine Geophysical Investigation. An explanation or further description of where this might have been applied could be offered.

“Horizontal positioning of the (drilling) barge was accomplished… with independent verification from the tug’s GPS system.”

---- Was a Trimble Pro XR GPS system also on the tug? How was the “independent verification from the tug” determined?

---- “Vertical Control” maintained by the tug’s fathometer and “conventional sounding line” has not been detailed. What equipment was on the tug for these measurements? Does “Vertical Control” mean a semi-accurate depth measurement to estimate the datum for drilling?

A.3 Instrumentation

A.3.2

“The acoustic energy sources were towed astern…”

----How was the position of the source and receiver adjusted for distance from the antennae?

A.3.3 Seismic Refraction Instrumentation

Seismic Refraction is a geophysical tool that is used to discern changes in geology, especially faulting and changes in lithology or stratigraphy.

A.3.4 Electrical Resistivity Instrumentation

Using special software, the electrical resistivity can be used to create a geologic cross-section of the study area. --- no cross-sections from ER were offered in the report.

---- Side Scan Sonar for Cross Reference

---- Side Scan Sonar is notably absent from this program and reference is not made to reviewing records collected during the geophysical program to corroborate conditions. For example, in section 5.0 Bottom and Subbottom Conditions, 5.2 Zone 5, “The shelf sediment is interpreted to be medium to coarse sand with patches of gravel and some cobbles”. Cross referencing to Table 1 of the Geophysical Investigation, Zone 5, the Geology is described as 10-15 feet of medium grained sediment on shelf; glacial sediment on slope”. These two descriptions are significantly different.

A.4 QA/QC procedures

Quality Assurance and Quality Control Procedures should show how the data was handled and processed, what problems were presented, and how quality control procedures were applied. Neither the geotechnical nor geophysical report contains this information.

3.2 Geophysics

“The marine refraction data were acquired on four locations at each of the five sites. These locations were generally in water depths of less than 30 feet.”

--- Twenty separate marine “shots” were made distributed among the five sites… Terrestrial geophysical investigations were conducted in two locations…. A seismic and electrical resistivity imaging profile were obtained at this location…”

---This data is not presented in any tabular form to indicate where it was collected, or graphically depicted for any of the sites addressed in the report.

“Appendix A includes a detailed description of the methods and instrumentation used for the geophysics program”

--- There is a description of the methods and instrumentation. It is not detailed. How the system was applied, positioned, and operated is not described. There are no figures that show how the data is represented for interpretation.

3.3 Borings and Laboratory Testing

"Geotechnical borings were completed in Zones 6,7,…."

--- There is no discussion, or rationale, for the selection of the boring sites. Were the sites selected based on the geophysical data interpretation?

--- There is no discussion, or rationale, for the selection of boring intervals for geotechnical sampling and testing. The depths of "grab" sampled in each core is reported relative to MSL. According to the Geophysical Report, 3.3.1 Precision Echosounder, those data were reduced to MLLW.

4.0 Regional and Geologic Setting

4.1 Geologic Setting

The science in this section is acceptable. However, cross-referencing with section 6.0 references, only half of the citations listed were found in the text while others were completely missing (i.e. Heaton and Harzell, 1992). Updating the reference list might also be in order, for example; Borden and Troost, 2000, was listed as "in press" as of 2000. This reference might have been published by May of 2002. With reference to

Appendix C – Seismicity of Puget Sound

There was no reference section.

4.2 Seismic Setting

p.8 "The expected probabilistically derived earthquake shaking in the project are, in terms of peak ground acceleration (PGA) is about .31g (per cent gravity) with a 10-year probability of exceeding this value in 50 years (USGS, 2002). "

---- There is no means offered to determine whether the PGA suggests this is a high, medium, or low risk area.

5.0 Bottom and Subbottom Conditions

5.1 General

"Table 1 summarizes the general characteristics of each of the sites and Table 2 summarizes the information from the offshore borings."

TABLE 1 – The slopes are labeled in percentages instead of units of degree. Please verify units, as percentages have not been used previously.

5.2 Zone 5

(Bottom and Subbottom Conditions, 5.2 Zone 5, "The shelf sediment is interpreted to be medium to coarse sand with patches of gravel and some cobbles". Cross referencing to Table 1 of the Geophysical Investigation, Zone 5, the Geology is described as 10-15 feet of medium grained sediment on shelf; glacial sediment on slope". These two descriptions are significantly different. Could this be verified with the side scan sonar (from) the March 2001 effort?

--- What was the rationale for not completing a boring in Zone 5?

5.3 Zone 6

5.3.1 Geophysical Data

A.3.4 "Using inversion software, a 2-D resistivity cross section is created using the apparent resistivity values. This cross-section can then be interpreted and presented"

--- It is unclear whether enough data was collected in this onshore area to allow a cross-section to be constructed.

5.3.2 Borehole Data

Does the low blow count/ low density estuarine materials extending to 95' depth make this area more susceptible to seismic activity?

5.4, 5.5, 5.6

No comment

Figures

Figure 2: Reflection Profile Example: This is an excellent example of the type of data that could be presented for each site.

Figure 3: Has no scientific value. It is a neat rendition of what I believe to be the multibeam data along the area of concern. However, there is no land base for reference, except for site labels, no vertical scale, no vertical exaggeration noted, and no compass rose for orientation.

Sheet 1 through 4 – See notes in Executive Summary

Appendix A-

3.2 Geophysics & Appendix A – geophysical methods and Instrumentation was addressed in the executive summary.

Appendix B- Boreholes

In the title section of each bore hole, the Elevation Source is listed as GPS. What is the vertical accuracy of the elevation, based on the measurement being taken from an antenna on a moving barge?

Appendix C- Seismicity of Puget Sound

This is a good scientific treatise of seismicity in Puget Sound. However, there was no accompanying reference sheet that listed the sources.

Four faults have been sited within 30 miles of the outfall area. The CDE PGA for the outfall area is 0.31g. There is no table that might indicate what the damage might be for this level of earth movement.

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

--NOT PROVIDED FOR THIS TECHNICAL DOCUMENT--

General questions pertaining to slope:

1. "Was the slope measured from the single beam echosounder information?"
2. "Or is it possible to isolate the center beam of the Reson unit (I didn't think so)?"
3. "Or was the slope averaged from bin averaged slopes created by the Reson system?

From the Zone 5 discussion in the Executive Summary:

1. "What is the prognosis of the [submarine/headwall erosional feature located within 300 feet of the A-A centerline at a water depth of ~450 feet] slope failure migrating up dip in order to attain equilibrium?"

From the Figure: Geologic Profile Zone 6 – Sheet 2:

1. "In the figure the core BH-1A has a label "Projected 330' South;" Is the figure projected 330' south of its actual location?"

From the Zone 7S Shallow discussion in the Executive Summary:

1. Regarding a "localized zone of boulders:" "Did these boulders show up on the seismic reflection data as hyperbole?"

From Section 3.2:

1. "What is the difference between parallel to the slope and perpendicular to the shoreline?"

From Section A.2, Navigation:

1. "Was a Trimble Pro XR GPS system also on the tug?
2. "How was the "independent verification from the tug" determined?"

"'Vertical Control' maintained by the tug's fathometer and 'conventional sounding line' has not been detailed."

3. "What equipment was on the tug for these measurements?"
4. "Does "Vertical Control" mean a semi-accurate depth measurement to estimate the datum for drilling?"

From Section A.3.2:

"The acoustic energy sources were towed astern…"

1. "How was the position of the source and receiver adjusted for distance from the antennae?"

From Section 3.3, Boring and Laboratory Testing:

1. "Were the sites selected based on the geophysical data interpretation?"

From Section 5.2, Zone 5:

"Bottom and Subbottom Conditions, 5.2 Zone 5, "The shelf sediment is interpreted to be medium to coarse sand with patches of gravel and some cobbles". Cross referencing to Table 1 of the Geophysical Investigation, Zone 5, the Geology is described as 10-15 feet of medium grained sediment on shelf; glacial sediment on slope”. These two descriptions are significantly different.”

1. “Could this be verified with the side scan sonar (from) the March 2001 effort?”
2. “What was the rationale for not completing a boring in Zone 5?”

From Section 5.3.2, Borehole Data:

1. “Does the low blow count/ low density estuarine materials extending to 95’ depth make this area more susceptible to seismic activity?”

From Appendix B – Boreholes:

“In the title section of each bore hole, the Elevation Source is listed as GPS.”
“What is the vertical accuracy of the elevation, based on the measurement being taken from an antennae on a moving barge?”

Document 3: *Submarine Cultural Resources. September 2001*

Coordinator's Summary

The individual peer reviewer examined the brief technical document and provided comments throughout. First, in some states, a "certified/licensed Archeologist" is required to participate in cultural surveys, as well as to evaluate any documents. Next, questions were raised about the type of acoustic signatures that were expected if a buried shipwreck were encountered. Further, a magnetometer should be utilized with side scan sonar to thoroughly survey the final outfall corridors for cultural artifacts. Lastly, the two figures in the document are illegible.

Document 3: *Submarine Cultural Resources*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Report Reviewed- Appendix E
Submarine Cultural Resources

February 19, 2003

Douglas R. Levin, Ph.D.
Geologist for Marine Outfall Siting Study (MOSS) Peer Review
BrightWater Marine Outfall Siting Study

Summary

The Submarine Cultural Resource is a technical memo. The perfunctory literature review discusses what cultural and engineering hazards might be encountered in the outfall corridors. In some states there is a requirement that a certified/licensed Archeologist review these documents and actively participate in the field program design, data collection and analysis.

2.0 Sunken Vessels, p.2

"Furthermore, the subbottom reflection data did not detect any buried objects that might be interpreted as sunken vessels"

This statement suggests that the seismic data was reviewed for the possibility of shipwrecks or other anthropomorphic objects.

----What would the acoustic signature be for a sunken vessel?
----Considering the geophysical trackline spacing what would be the likelihood of seeing a parabola caused by a shipwreck?
----How would a parabola from a boulder be distinguished from a possible shipwreck?

3.0 Cable Areas, p.3

This paragraph is largely correct. When the final outfall corridor candidates have been identified a thorough survey using a magnetometer, in addition to the other suite of equipment, at close line spacing should be employed.

Figures

---- The figures on page 5 and 6 of this document are not legible.

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

--NOT PROVIDED FOR THIS TECHNICAL DOCUMENT--

From the full text review, Section 2.0:

1. What would the acoustic signature be for a sunken vessel?
2. Considering the geophysical trackline spacing what would be the likelihood of seeing a parabola caused by a shipwreck?

1. How would a parabola from a boulder be distinguished from a possible shipwreck?

APPENDIX B-3

Core Subject Area →	**Hydrodynamic Modeling**
MOSS Technical Documents Reviewed →	1. *Initial Dilution Assessment of Potential Diffuser Zones, Moss Plume modeling: Continuous discharges to Puget Sound, Phase 2. September 2001*
	2. *Brightwater Marine Outfall: Phase 3 Initial Dilution Assessment of Potential Diffuser Zones. November 2002*
	3. *Brightwater Marine Outfall: Puget Sound Marine Modeling Report. November 2002*
Peer Reviewer →	**Philip J.W. Roberts,** Ph.D., PE, Modeling and Engineering, Georgia Institute of Technology

<u>*Document 1*</u>*: Initial Dilution Assessment of Potential Diffuser Zones, Moss Plume modeling: Continuous discharges to Puget Sound, Phase 2.*

<u>Coordinator's Summary</u>

As one of the determining factors of plume behavior, the current variability was not discussed and "only two current speeds…[were] used in the simulations." Instead of using estimated values, time-series records from the current speeds "would be preferable to use…directly in the simulations." Lastly, the methods used to select the four density profiles were not stated. "It would be desirable to show the actual data on which they were based."

Except for the shallowest depth, 100:1 dilutions "[were] fairly easy to achieve for all sites," and the plume "was always submerged." Also, "more refined modeling" would not likely change this assessment. The "considerable variability in the mean current speed…has strong implications for the ultimate fate of the wastefield." Finally, the reviewer stated the "plume trapping depth should be near the surface" for the greatest flushing. However "the probability of shoreward transport" increases with this, thus "the final design should carefully consider the tradeoff between these two factors."

<u>Recommendation</u>: 1) "The variability of the plume rise height through the tidal cycle should be more carefully modeled. This may require additional continuous measurements of density stratification."

Document 1: *Initial Dilution Assessment of Potential Diffuser Zones, Moss Plume modeling: Continuous discharges to Puget Sound, Phase 2.*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Review Date: March 24, 2003

Reviewer: Dr. Philip J. W. Roberts

Document: Initial Dilution Assessment of Potential Diffuser Zones. MOSS Plume Modeling: Continuous Discharges to Puget Sound

General Comments

This report discusses the initial dilution modeling. As previously discussed, the model RSB is used.

The plume behavior, i.e. initial dilution, is mostly determined by the diffuser characteristics, the current speed and direction, and the density stratification. In Puget Sound the currents change continually, mostly as a result of the semi-diurnal (M2) tide. There is no discussion of this current variability, however, and only two current speeds: the 10% and 90% values are used in the simulations. As time-series records are available from the current meters, it would be preferable to use this data directly in the simulations. The 10% and 90% current speeds used are estimated from the current meters. The regression procedures used to do this (Section 2.3.1) are not clear, however. Only four density profiles are used (Table 8): Strong summer, average summer, average winter, and weak winter. It is not stated how these profiles were chosen, and it would be desirable to show the actual data on which they were based.

The assumed diffuser depths range from 34 to 238 meters. For all depths, except the shallowest site, the plume was always submerged. Because the oceanographic data reports show considerable variability in the mean current speed, and therefore flushing, with depth, this has strong implications for the ultimate fate of the wastefield. The variability of the plume rise height through the tidal cycle should be more carefully modeled. This may require additional continuous measurements of density stratification.

The main conclusion is that dilutions of 100:1 are fairly easy to achieve for all sites, except the shallowest one. Again, more refined modeling is unlikely to change this conclusion. Mean current speeds increase towards the surface, so for best flushing the plume trapping depth should be near the surface. This increases the probability of shoreward transport, however, so the final design should carefully consider the tradeoff between these two factors.

QUESTIONS FOR THE MOSS TEAM

No questions from the reviewer.

Document 2: *Brightwater Marine Outfall: Phase 3 Initial Dilution Assessment of Potential Diffuser Zones. November 2002*

Coordinator's Summary

Comments from the Phase 2 report apply here. In addition, statistical analyses should have included more data, and a "more thorough analyses of the plume rise height and dilution for various diffuser designs should be undertaken."

Document 2: *Brightwater Marine Outfall: Phase 3 Initial Dilution Assessment of Potential Diffuser Zones. November 2002*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Review Date:	March 24, 2003
Reviewer:	Dr. Philip J. W. Roberts
Document:	Brightwater Marine Outfall Phase 3 Initial Dilution Assessment of Potential Diffuser Zones

General Comments

This report documents in further detail the initial dilution modeling at the three potential diffuser sites.

Similar comments to those made previously apply. Only two stratifications and two current speeds were used at each site. The current direction was assumed to be always perpendicular to the diffuser. This assumption is not necessary. More data should be incorporated into statistical analyses, as previously discussed, and more thorough analyses of the plume rise height and dilution for various diffuser designs should be undertaken.

QUESTIONS FOR THE MOSS TEAM

No questions from the reviewer.

Document 3: *Brightwater Marine Outfall: Puget Sound Marine Modeling Report. November 2002*

Coordinator's Summary

The modeling should have been better linked to the extensive oceanographic data that were available. Only a portion of the data was "advantageously used," with the drogue and dye release data not used at all. Additional modeling and measurements "should be more closely coordinated to ensure that data directly applicable and useful to the modeling effort are obtained."

Due to extremely complex circulation patterns in Puget Sound, "the model [did] not capture the essential features of the mean circulation" in some cases. Tidal heights were "predicted well," but density stratifications were "only approximately reproduced." Nevertheless, the reviewer stated "the main predictions of the model [were] probably correct: That the plume remains submerged with little shoreline impact." Transport to shoreline is critically dependent "on the rate of vertical mixing," which is dependent on density stratification. Comprehensive data on density stratification was lacking (e.g., "continuous measurements").

Finally, the horizontal grid size of the Princeton Ocean Model was "quite large relative to the diffuser length and so the results are not applicable in the immediate vicinity of the diffuser." Also, "predictions of stratification…over water depth" would more useful than predicted temperatures and salinities. The "differences in density…are more relevant to plume behavior and vertical mixing."

Recommendation: 1) "Transport of the effluent plume on time scales of the order of a few hours after release from the diffuser" should be given more attention. Also, "the predicted tidal currents, on time scales of a few hours should be addressed."

<u>Document 3</u>: *Brightwater Marine Outfall: Puget Sound Marine Modeling Report. November 2002*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Review Date: March 24, 2003

Reviewer: Dr. Philip J. W. Roberts

Document: Brightwater Marine Outfall Puget Sound Marine Modeling Report

General Comments

This report describes the use of a numerical circulation model, the Princeton Ocean Model (POM), to predict circulation in Puget Sound and long-term wastewater transport. The model is three-dimensional and assumes 14 layers in the vertical. The horizontal grid size is 600 by 900 m. This is quite large relative to the diffuser length and so the results are not applicable in the immediate vicinity of the diffuser.

Calibration efforts show that the tidal heights are predicted well. Only comparisons with mean currents are shown; some of the comparisons are reasonable, but in some cases the model does not capture the essential features of the mean circulation. This is mainly due to the extreme complexity of the circulation patterns in Puget Sound, as revealed by the extensive oceanographic investigations. Density stratifications are also only approximately reproduced. Despite these caveats, the main predictions of the model are probably correct: That the plume remains submerged with little shoreline impact. Whether the plume mixes upwards and is transported to shore depends critically on the rate of vertical mixing. This in turn depends on density stratification, detailed data on which is lacking.

The model and measured mean current speeds are shown with different color scales, which makes it difficult to compare them.

I would recommend that more attention be given to transport of the effluent plume on time scales of the order of a few hours after release from the diffuser. This is because these time scales usually result in the highest impacts at locations within a few kilometers from the source. Effluent transported for longer times are thoroughly mixed by estuarine processes, and any bacteria subject to decay. The predicted tidal currents, on time scales of a few hours should be addressed.

The predicted temperatures and salinities are shown as absolute values only. It would be more useful to show predictions of stratification, i.e. differences in density over water depth, as these are more relevant to plume behavior and vertical mixing.

Overall, there should be more linkage between the modeling and the very extensive oceanographic data that have been obtained. Only a small fraction of this data has been advantageously used and much useful data, particularly the drogue and dye releases, does not seem to have been used at all. Extensive as it is, the oceanographic data appears to be deficient in continuous measurements of density stratification. The stratification may not turn out to be highly variable, but the issue should be addressed. If further modeling and measurements are made, they should be more closely coordinated to ensure that data directly applicable and useful to the modeling efforts are obtained.

QUESTIONS FOR THE MOSS TEAM

No questions from the reviewer.

APPENDIX B-4

Core Subject Area →	**Marine Resource Biology**
MOSS Technical Documents Reviewed →	1. *Brightwater Marine Outfall: A Geoduck (Panopea abrupta) Survey for the King County MOSS. November 2002*
	2. *King County Marine Habitat Report Prepared in support of the Wastewater Treatment Division, Habitat Conservation Plan, and the Brightwater Marine Outfall Siting Study. January 2001*
	3. *Biological Resources Report, Phase 2. September 2001*
Peer Reviewer →	**Aimee A. Keller,** Ph.D., Marine Research Biologist, Puget Sound region, University of Rhode Island
MOSS Technical Documents Reviewed →	4. *Brightwater Marine Outfall Phase 3 Biological Resources Report. November 2002*
	5. *King County Nearshore Habitat Mapping Data Report: Picnic Point to Shilshole Marina. March 2001*
	6. *Submerged Aquatic Vegetation Patterns in Candidate Outfall Zones. September 2001*
Peer Reviewers →	**Aimee A. Keller, Douglas R. Levin,** and **Michael S. Connor**, Ph.D., Ecologist, San Francisco Estuary Institute.

Document 1: *Brightwater Marine Outfall: A Geoduck (Panopea abrupta) Survey for the King County MOSS. November 2002*

Coordinator's Summary

Comments were provided for variables measured, measurement methods, sample design, and data analysis. The main variables selected for measurement "[were] appropriate to the study," as was information on eelgrass "for extending the known area…beyond the range previously identified." The reviewer questioned why the quantitative data on gaper clams was not analyzed, and commented that results for sea cucumber and Dungeness crabs "[were] probably not useful." Also, "the list of associated biota really [did] not add much to the study."

The methods for the geoduck survey were modified somewhat for safety, although "no explanation was given as to how [the modified protocol was] a safer dive pattern." Nevertheless, the modifications "were approved by WDFW…and considered comparable to techniques used during prior studies." The methods used for the geoduck show study were also appropriate, and "based on previously established protocols." "The method used to grade the geoducks [was] somewhat subjective but interesting and well-explained." Lastly, the method used to determine the sediment type was not mentioned.

The experimental design for the study "was scientifically acceptable and based on valid statistical surveying techniques" and "assured equal coverage of the potential outfall zones."

The "random element [introduced]…at the starting point for each grid line" did not seem appropriate, but since included, "should be explained in statistical terms." The design for sampling biomass at transects resulted in "very few samples being collected in subarea B." Thus, additional biomass samples should have been obtained from that subarea.

The reviewer revealed a possible error "with the count and density data for two transects from Alignment 6…incorrectly assigned to subarea C." The Figure 2 map "clearly show[ed] Alignment 6 in subarea B." "Consequently the statistics presented in Table 3 are incorrect and the ANOVA based on the classification by these subarea is also incorrect." In addition, abundance data are often logarithmically transformed prior to analyses. In response, the reviewer logarithmically transformed the count and density data and "redid the ANOVA (based on the reassignment of Alignment 6 transects to subarea B)." The results indicated "significant differences between transformed counts…and density," and another test "indicated that abundance in subarea A [was] significantly greater than subareas b and c."

The reviewer provided a graphical illustration plotting geoduck abundance versus depth. Instead of the "weak correlation between density and depth" reported in the text, "a threshold relationship between the two variables" was revealed. "This is an important finding and should be included in the results."

A second graphical illustration comparing length and weight of geoducks was provided. The reviewer examined the relationship via an exponential equation and revealed that the "fit of the equation [was] improved" for the measurements. The reviewer also "redid the ANOVA comparing geoduck abundance among the 4 candidate outfall zones, after logarithmically transforming counts." This revealed "significant differences among candidate outfall zones…with significant differences between Zone 5 and zone 7N..." Furthermore, geoduck abundance in outfall zone 5 "was significantly greater than outfall zone 7N, information of potential importance in siting the outfall."

Finally, it would be useful to include summaries in the text containing the methods and results for the geoduck grading study and the "total number of geoducks assigned to each grade in the outfall zone."

<u>Recommendations</u>: 1) "Given the significant differences among subareas and depths, additional analyses should be undertaken – perhaps a 2-way ANOVA or an analysis of covariance (ANCOVA);" and 2) Summarize in the main text the methods and results for the geoduck grading study.

<u>Document 1</u>: *Brightwater Marine Outfall: A Geoduck (Panopea abrupta) Survey for the King County MOSS. November 2002*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Review Date: February 11, 2003
Reviewer Name: **Aimee A. Keller**
Technical Document being reviewed: **A geoduck (*Panopea abrupta*) survey for the King County MOSS (phase 3)**

<u>General Comments</u>: The document describes a geoduck resource study designed to address the gaps uncovered in the existing data during the phase 2 biological resources study. Included in the document is a quantitative assessment of geoduck resources, an assessment of the commercial value of the resource, a qualitative assessment of associated biota, and additional information about the extent of eelgrass habitat. My general comments are subdivided into four categories: variables measured, measurement methods, sample design, and data analysis.

<u>Variables measured</u>: The variables selected for measurement during the actual survey were geoduck abundance, length, weight and condition (i.e. commercial value). In addition, a study was undertaken to determine a show factor. The show factor is an empirically determined value used to adjust the number of observed siphons to the number actually present, since not all siphons are exposed during the actual survey. Ancillary data collected during the survey included sediment type along each transect, information on eelgrass beds not obtained using earlier techniques, quantitative counts of gaper clams, Dungeness crabs and sea cucumbers and qualitative observations of additional species present. The primary variables selected for measurement (abundance, length, weight, condition and show) are appropriate to the study. I disagree with the authors' decision not to analyze the quantitative data on gaper clams and question why the data were collected and presented if they were not going to be used. Given the sparse counts for sea cucumber and Dungeness crabs, the results are probably not useful. The information on eelgrass is useful for extending the known area of eelgrass habitat beyond the range previously identified and therefore it was also an appropriate variable to include in the study. The list of associated biota really does not add much to the study, particularly since no effort was made to survey the additional biota in a comprehensive fashion.

<u>Measurement methods</u> – The measurement methods for the geoduck survey and show study were based on previously established techniques developed by WDFW and tribal shellfish managers for conducting similar surveys. The survey consisted of a series of transects along pre-established grid lines. A pair of divers observed and counted the number of geoduck siphons visible along either side of a grid line in consecutive transects 6 ft wide by 150 ft long. Each grid line extended from a depth of –70 feet MLLW shoreward to either the seaward extent of eelgrass beds, when present or a depth of –4 feet MLLW. Underwater obstructions occasionally altered the course somewhat. The established methods were modified slightly by starting at the deep end of the survey and working shoreward. Although the authors' indicate this was done for safety reasons, no explanation was given as to how this is a safer dive pattern. Nonetheless, the adjustments to the sampling protocol were approved by WDWF and consequently were

considered comparable to techniques used during prior studies. The lower boundary was chosen since –70 feet MLLW is the maximum depth for commercial geoduck harvest. The upper boundary was selected because of the interest of local Native American Tribes in the assessment of the intertidal portion of the population. The survey techniques were chosen to: 1) permit comparisons with historical surveys; 2) allow comparisons among different areas; 3) standardize methodology for future use; and 4) develop a database of value to managers. In addition to counting geoduck, counts were also made for gaper clams, sea cucumbers and Dungeness crabs.

Starting positions of divers along grid lines were determined using a GPS system with a resolution of 3 m. Compass direction was used to proceed shoreward. A more sophisticated underwater positioning system was used for transects along three possible candidate outfall pipeline corridors. The different positioning methods were chosen to provide additional precision as desired.

The methods for the show study were similarly based on previously established protocols specifically developed to determine the actual number of geoducks in an area relative to the number of siphons observed on a single dive. Because of the extent of the area studied, two plots were selected for the show study, one at the northern extent of the geographic area surveyed and another at the southern extent. The methods selected were appropriate for the show study. Could a similar empirical show factor have been developed for gaper clams?

A subset of transects surveyed for population abundance was subsequently chosen to estimate biomass. The selection was based on a minimum adjusted density of 0.4 geoducks m^{-2}. Although this is the threshold density for biomass sampling and commercial harvesting, some effort should have been made to collect additional samples in subarea B where only 5 geoducks were weighed and measured.

The method used to grade the geoducks is somewhat subjective. To account for individual differences in grading a blind test was conducted. The factors important in assigning grades to the geoducks were explained and photographs were included. The grade assigned to the geoduck determines the commercial value of the clam. The process was interesting and the method although qualitative is appropriate for assessing the value of the resource.

No mention is made of the method used to determine sediment type. Typically sediment classification is based on grain size as determined from sieving the sediment. If a qualitative assessment of sediment type was made based on visual observation by divers this should be noted.

<u>Experimental design</u> – A simple and complete experimental design was selected that assured equal coverage of the potential outfall zones. Beginning at the northern end of the study area, grid lines were established at 1000-foot intervals perpendicular to the shore until the southern extent was reached. A total of 26 grid lines were chosen in this fashion. Three additional grid lines were established along potential outfall pipeline corridors in three candidate outfall zones (Zones 6, 7N and 7S). The grid lines extended from the intertidal area to a depth of –70 feet MLLW. The number of 150-foot long transects along each grid line was a function of the bottom slope.

I am not sure why a random element was introduced into the starting position for each grid line. The inclusion of this element in the experimental design should be explained in statistical terms. Since a random, stratified design was not selected for the study, it does not seem appropriate.

The experimental design for selecting biomass transects was also selected to ensure that samples were spread throughout the study area. Eligible transects were assigned numbers and one was chosen randomly as a starting point. Every sixth eligible transect was subsequently selected for biomass sampling. Unfortunately, the criteria used to establish eligibility resulted in very few samples being collected in subarea B. Additional samples should have been added in this subarea.

The experimental design for the show study consisted of repeatedly surveying the show plots until no new geoducks were sighted. A flag marked each geoduck observed. The show factor was calculated by dividing the initial number observed during the 1st survey by the total number observed over repeated sampling. Raw counts during the actual survey were then adjusted to reflect actual abundance by dividing the raw count by the show factor.

In general, the experimental design was scientifically acceptable and based on valid statistical surveying techniques.

<u>Data analysis</u> – I believe the count and density data for two transects from Alignment 6 were incorrectly assigned to subarea C. I examined the data in Appendix A, Table 4 to compare with the summarized results in Table 3 of the main document. In Table 3, 17 transects are listed as occurring in subarea B and 67 in subarea C. I summed the transects from the Appendix for each subarea using the descriptions of which grid lines were assigned to each area in Sections 3.4.1; 3.4.2 and 3.4.3. The totals for subareas B and C did not match those given in Table 3. I noticed that Alignments 7N and 7S were stated as occurring in subarea C in section 3.4.3 but no mention was made of where Alignment 6 was included. For the number of transects to match the total of 140 given in Table 3, transects in Alignment 6 must be included. The map (Figure 2) clearly shows Alignment 6 in subarea B. The number of transects (67) assigned to subarea C in Table 3 is too high based on Appendix A (by 2 transects), while subarea B is too low (by two transects), suggesting that perhaps the difference was caused by incorrectly assigning the two transects in Alignment 6 to subarea C. Consequently the statistics presented in Table 3 are incorrect and the ANOVA based on the classification by these subareas is also incorrect.

In general, a natural logarithmic transformation is applied to abundance data prior to statistical analysis (ANOVA) to reduce variation due to the occurrence of extreme values and more closely approximate a normal distribution. I transformed the count and density data using the transformation ln (count +1) and redid the ANOVA (based on the reassignment of Alignment 6 transects to subarea B). The results indicated significant differences between transformed counts ($F = 5.2$, $P = 0.007$) and density ($F = 4.21$, $P = 0.02$). A Student-Kewman-Keuls test for differences among means indicated that abundance in subarea A is significantly greater than subareas b and c.

Given the significant differences among subareas and depths, additional analyses should be undertaken – perhaps a 2-way ANOVA or an analysis of covariance (ANCOVA).

The authors mentioned that there was a weak correlation between density and depth. To examine the relationship, I plotted abundance versus depth (Figure 1). I was surprised to see that the figure indicates a threshold relationship between the two variables, which is an important finding and should be included in the results.

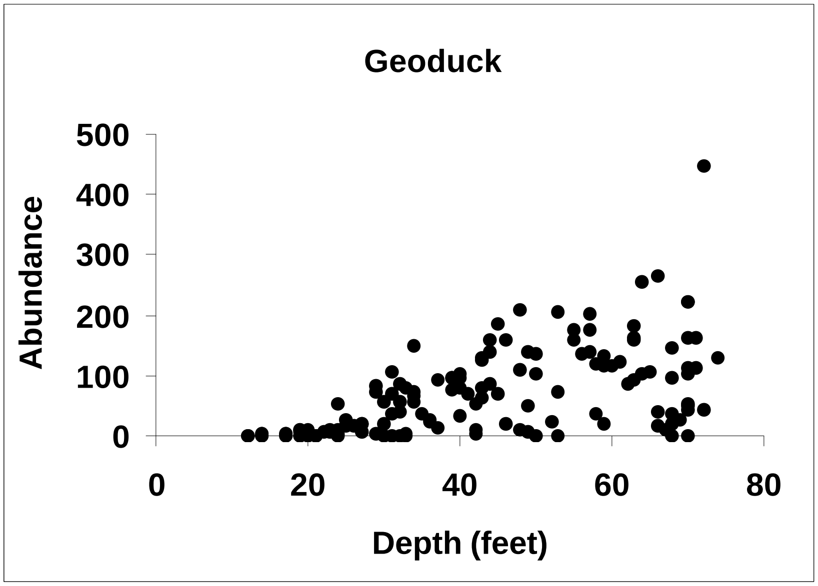


Figure 1. Relationship between geoduck abundance (subareas A, B, and C) and depth (feet).

The analysis for geoduck biomass revealed significant differences among areas and depths. Again a 2-way ANOVA or an ANOCOVA might provide additional information of use in siting the outfall.

The authors noted a strong correlation between length and weight (r=0.81). I examined this relationship since an exponential equation is typically used to compare length and weight but the authors seemed to imply that a linear fit was applied. As expected, an exponential fit is appropriate for the measurements and the fit of the equation is improved (r=0.91) (Figure 2). However, examination of the initial plot revealed 2 outliers (wt 1910 g-length 146.3 mm; wt 1515 g-length113.0 mm). I removed these points as statistical outliers but the data should be rechecked, since they may be transcription errors. Nonetheless, an exponential fit is appropriate and the linear fit gave the correlation coefficient found by the authors, so I suspect they did not try the exponential.

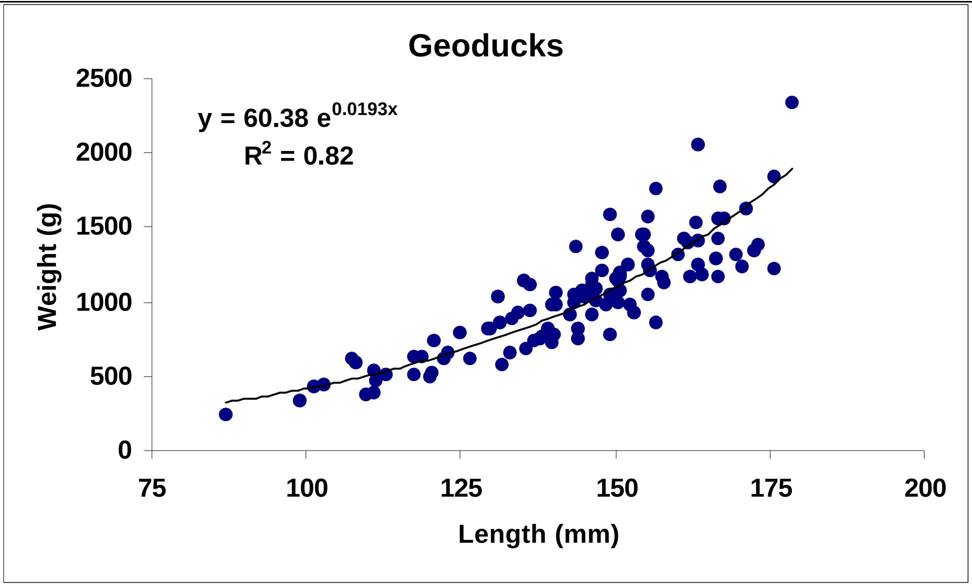


Figure 2. Length (mm) versus weight (g) for the geoducks collected from subareas A, B and C in the MOSS outfall study site.

I also redid the ANOVA comparing geoduck abundance among the 4 candidate outfall zones, after logarithmically transforming count, as above. Based on the map (Figure 2), I assigned grid lines 5, 6 and 7 to outfall zone 5, grid lines 12, 13 and A6 to outfall zone 6, lines 15, 16, 17, 18 and A7N to outfall zone 7N and lines 21, 22, 23 and A7S to outfall zone 7S. Using these data, the ANOVA reveals significant differences among candidate outfall zones (F=7.39, P=0.003) with significant differences between zone 5 and zone 7N but not among 5, 6 and 7S or 6, 7N or 7S. Abundance in outfall zone 5 was significantly greater than outfall zone 7N, information of potential importance in siting the outfall.

I think a summary of the methods and results for the grading study should be included in the main body of the text rather than all of the information being confined to an appendix. The figures and detailed information could remain in the appendix but a short summary of methods and appropriate summary tables should be added to the text, The value of the geoducks in the different potential outfall areas is of use in siting the final outfall position.   At the minimum a summary table showing the total number of geoducks assigned to each grade in each outfall zone should be included.

Summary – Great design, appropriate variables and methods; analysis could use a little work.

Specific comments

Page ii – I disagree with the finding in the final paragraph that there were no significant differences among the subareas or candidate outfall zones in geoduck abundance (count and density) based on my analysis.

Page iv – Appendix C – I could not find the comments by WDFW in this appendix

Page v – Table 1 – I am not sure what is meant by the phrase ‘with the lower edge of eelgrass’ in the table header. Should it be ‘beyond the lower edge’?

Page 1, paragraph 2, line 5. ‘Accepted four candidate’ should be ‘accepted’ with a lower case ‘a’

Page 4, Section 2.2.1, paragraph 1, line 4 – The lower limit of the grid line is listed as 80 ft MLLW in this section but 70 feet throughout the remainder of the document.

Page 5, line 1 change ‘together has been’ to ‘together have been’

Page 6. Section 2.2.3, paragraph 2, line 2. Change ‘selected for sampling’ to ‘selected for biomass sampling’

Page 6, Section 2.4. Delete ‘are’ after the)

Page 7, Formula 3 nD should be n_D

Formula 4 – appears incorrect I think it should be

Variance $\delta^2_D = (\sum d_i^2 - (\sum d_i)^2/n_D)) / (n_D - 1)$

Then the standard deviation is S_D = sq. root of d^2_D

And standard error $SE_D = S_D$ / (square root of n_D) which is not obvious from Formula 5

Formula 6 the denominator should be mean density which is not obvious and most frequently the result is based on standard deviation (not standard error) and converted to a percent

Formula 7 CI_D = D (again this is mean D and needs to be properly represented in the formula)

Formula 8 wi should be w_i and nW should be n_W

Formula 9 – appears incorrect and should be

Variance $\delta^2_W = (\sum w_i^2 - (\sum w_i)^2/n_w)) / (n_w - 1)$

Then the standard deviation is S_W = sq. root of d^2_W

And standard error $SE_W = S_W$ / (square root of n_W) which is not obvious from Formula 10

Formula 11 – see notes on formula 6 and add appropriate subscripts

CVW should be CV_W

Typographically SEW should be SE_W but really should be based on S_W

Formula 12 CIW should be CI_W

Page 8, Section 3.3, line 5 change ‘…total length was’ to ‘….total length were’

Page 9 – Change table header to ‘beyond the lower edge…’ or ‘and the depth of the lower edge of the eelgrass bed’ or ‘Dominant substrate type and depth of the lower edge of the eelgrass bed for each grid line in the MOSS …”
Also some of the table is beyond the right margin and is not printed

Page 10, Section 3.4, paragraph 1, line 7. Change ‘particle sizes is’ to ‘particle sizes are’

Page 10, Section 3.4.1, Paragraph 2, lines 3-4 change ‘Because power vessels are not allowed within the park because of potential danger to recreational scuba divers using the park, the survey’ to ‘Power vessels are not allowed within the park because of potential danger to recreational scuba divers. Consequently, the survey’

Page 11, paragraph 2. The cabezon mentioned as being observed while spawning is not included in the list of other biota in Table 2 or Appendix A, Table 7

Page 11, Section 3.4.2. Mention here that Alignment 6 is included in subarea B

Page 13, Section 3.5, paragraph 3. Italicize the species name for kelp – not just the genus

Page 14, paragraph 2, line 4. Change ‘count data on gapers likely does not’ to ‘ count data on gapers likely do not’

Page 16. Table 3. Correct the values in the table for the error noted above in assigning transects to subareas. Also the lines in the table are incorrect – remove the column line in the “Sub Area” header so that in goes across A, B and C not just A and B.

Page 17. Table 4. Add units for mean density (number m^{-2} or number ft^{-2})

Page 19, Section 3.8, line 10. The open parenthesis at the end of the line needs to be moved so that it is not isolated from the citation to which it belongs.

Page 20, conclusions – Bullet 7. Change ‘ data does’ to ‘data do’ (sigh). Rewrite the bullets after redoing the statistics since there are several additional statistical differences among counts (and density).

Page 21, Literature Cited
Bradbury – italicize *Panopea abrupta*
Goodwin 1977 – italicize *Panopea generosa*
Goodwin and Pease 1991– italicize *Panopea abrupta*

Figures are beautiful

Figures 11, 14 and 15. Define the error bars – are they standard errors or standard deviation?

Appendix A, Table 4, page 4 of 4. I could not find the unassigned zone referred to by footnote 2

Appendix A, Table 5, page 1 of 3. The weight in pounds listed for line 7, 10-May, depth 12.8 feet is given as 11.55 lbs. If the weight in g is correct then the weight in pounds should be 2.55 lbs.

Appendix A, Table 6. The units are misrepresented by listing them as (m/ft) and (g/lbs). Place the correct units at the top of the corresponding column using the convention followed throughout the text i.e m (ft) or g (lbs)

Appendix A, Table 7 – This table appears in the text already as Table 2

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

--NOT PROVIDED FOR THIS TECHNICAL DOCUMENT--

<u>Aimee Keller</u>

General question pertaining to methods for the show study:
"The methods selected were appropriate for the show study.
Could a similar empirical show factor have been developed for gaper clams?"

From Table 1 (page v):
"I am not sure what is meant by the phrase 'with the lower edge of eelgrass' in the table header.
1. Should it be 'beyond the lower edge'?"

From Figures 11, 14, and 15:
"Define the error bars – are they standard errors or standard deviation?"

Document 2: *King County Marine Habitat Report Prepared in support of the Wastewater Treatment Division, Habitat Conservation Plan, and the Brightwater Marine Outfall Siting Study. January 2001*

Coordinator's Summary

Generally, the report was "well written, focused and easy to understand." The reviewer acknowledged the author's effort to gather existing information relevant to species and habitats, as well as identifying data gaps. Species distribution and abundance maps were provided, showing abundance data were sparse for juvenile salmonids. The format for the marine bird distribution maps would work well for the salmonids and marine fish. It was noted, "data presentation should be improved or…clearly stated that data were so sparse that distribution maps [for juvenile salmonids and marine fish species] could not be generated." Lastly, the data and maps in Appendix B were "particularly difficult to interpret and should be replotted in a better format."

Additional comments included providing a salmonid summary table for "each geographic subsection" (similar to the marine fish tables) and "annual plots showing the decrease in abundance for [marine fish such as cod, pollock, hake and lingcod]." Also, seine net dimensions and "area swept" should be specified to allow for catch comparisons "between years and areas." Finally, the reviewer commented on the need for consistent reporting of measurement units throughout the document, and cross-referencing information in other reports when relevant to this document (e.g., some vegetation abundance data in the Submerged Aquatic Vegetation document is relevant here).

Document 2: *King County Marine Habitat Report Prepared in support of the Wastewater Treatment Division, Habitat Conservation Plan, and the Brightwater Marine Outfall Siting Study.*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Review Date: February 6, 2003
Reviewer Name: **Aimee A. Keller**
Technical Document being reviewed: **King County Marine Habitat Report: prepared in support of the wastewater treatment division habitat conservation plan and the Brightwater marine outfall siting study**

General Comments: This is a well written document reviewing the existing habitats, marine species of interest and major data gaps in species information for wastewater discharge areas within King County and Southern Snohomish County. The compiled information is a pre-requisite for preparing a Habitat Conservation Plan (HCP). The HCP is a necessary step in acquiring an incidental take permit under Section 10 of the Endangered Species Act (ESA). The report begins with a series of species profiles for 41 marine species (marine mammals, birds, fish and invertebrates) that are under consideration for inclusion in the HCP. The 41 species are either threatened species or candidate species for listing under the ESA that may occur in the portion of Puget Sound of interest. The report is further subdivided into 3 geographical areas. One subsection is devoted to the Brightwater outfall siting area. The remaining two areas included regions to the south of the potential Brightwater outfall designated as the wastewater treatment division existing discharge area and the Vashon Island area. Although this approach results in a somewhat repetitious presentation of material it is useful for focusing attention on specific regions of the Sound. This is particularly important to managers involved in assessing impacts to a single area of the Sound.

A conscientious effort was made to uncover all data pertaining to habitats and species of interest including contacting local entities with management, research or other interests in the area. Much of the literature available was present in unpublished reports. I am always surprised by the limit to the existing information for marine organisms within the Sound. Nonetheless the report does a good job of gathering together the existing information and then identifying the areas where information is lacking.

In general, the report is well written, focused and easy to understand. The authors identify both historical and recent information. Habitat maps and species distribution maps are included. The format adopted for distribution maps for marine birds should be used for salmonids and marine fish as well. Although information on juvenile salmonid abundance was sparse at the time the report was written, additional information appears to be forthcoming in a report by Mavros and Brennan (in prep.). Given the importance of juvenile salmon and other marine fish species the data presentation should be improved or it should be clearly stated that data were so sparse that distribution maps could not be generated. If WDFW trawl and video data are sufficient, perhaps graphs could be generated from the data listed in appendix C, showing abundance and seasonal patterns. The maps and data presented in Appendix B were particularly difficult to interpret and should be replotted in a better format.

Units were often reported in the metric system but not always – units should be converted to be consistent throughout the document.

A table for the salmonid portion of each geographic subsection would be useful in summarizing the results and permit comparisons among the 3 regions (similar to the marine fish tables included with each subsection).

It was mentioned for several species of marine fish (cod, pollock, hake, lingcod) that abundance had declined in recent years due to overfishing or perhaps climate change. Annual plots showing the decrease in abundance for these species would be informative.

The relatively small area that was reported as forage fish spawning habitat in the report surprised me. Perhaps the recent forage fish surveys that were discussed at the kick-off meeting for the review team occurred after the report was written.

Dan Penttila refers to herring as *Clupea pallasi* in his recent reports and yet the species is called *Clupea harengus pallasi* throughout this document. Has the name changed recently?

Several references are made to a specific number of a given fish species collected via seine haul throughout the document. To compare catch between years and areas information needs to be given about the size of the net and the area swept.

<u>Specific Comments</u>

List of Figures – Figure 4-1 legend should be relabeled as Bathymetric contours in the WTD Existing Discharges Area
Figure 4-2 legend should have 'Area' added to the end of it

Page 1, paragraph 2, line 4 add 'ESA' after endangered species act
Page 14, Harlequin Duck – Ecological Role, line 7 change 'feed on same prey' to 'feed on the same prey'
Page 15, section 2.2 paragraph 2 – line 3 change 'from all other fish' to 'all other local fish' - since many deep-sea and midwater species also have adipose fins.

Same page, paragraph 3, line 3 change 'considered an important factor to be considered' to 'identified as an important factor to consider'

Page 19 paragraph labeled <u>Ecological role</u> – line 5 – I do not know what the numbers in parentheses mean (63 FR 31693)?????

Page 43 End of paragraph 2- mixed coarse, the mixed coarse needs to refer to something like sand or gravel

Page 47 paragraph 2, line 4 change ‘two year period he noted’ to ‘two year period they noted’
Page 47, paragraph 2, line 6 change ‘largest diversity of fish were’ to ‘greatest diversity of fish was’. Also the use of depth interval is a little confusing in this paragraph since it is referring to a single depth rather than a range
Page 57, Olympia oyster paragraph – change ‘Site-specific information of’ to ‘Site specific information for’

Page 80 – Table 3-1 units should be consistent: depth range is given in feet and density in individuals/m^2

Page 84 1st paragraph, line 6 change ‘that wide a variety’ to ‘that a wide variety’

Page 88, paragraph 4, line 6 change ‘from WDFW (1993) was’ to ‘from WDFW (1993) were’

Page 90 last paragraph, line 1 change ‘1973 was’ to ‘1973 were’

Page 98 the figure has the wrong legend – change to Figure 4-1. Bathymetric contours in the WTD existing discharge area

Page 110 section 5.1 final paragraph refers to depth in meters but figure shows feet

Page 111 section 5.2.1 line 5 change ‘and includes of overhanging’ to ‘and includes overhanging’

Page 116 section 5.3.4 line 7 change ‘in the this area’ to ‘in this area’

Page 118 Sand Lance section, line 2 – remove extra parentheses in front of (one

Page 140 final paragraph – notes that information on vegetation abundance in intertidal and subtidal zones is lacking – these data are now available in the Submerged Aquatic Vegetation report and should be cross referenced.

Page 146 Balcomb et al. 1980 whales is misspelled as khales

Page 154 Penttila 1995 – genera need to be italicized

Page 155 Sandercock 1991 – species needs to be italicized

Appendix A – several times in this appendix the word data is coupled with a singular verb or participle–they should be plural, the singular of data is datum.

Page A-6, A-7 Several times in this table the principal prey taxa and adjoining food web comment are improperly aligned ex. line 1 *Clupea harenga* is adjacent to the comment ‘unidentified fish’ and Teleostei is next to ‘herring’. These lines need to be reversed so that they are adjacent to the appropriate comment; also the stage is not always completely printed and italics are not used for species names.

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

Responses provided by Kim Stark, King County DNR

General question pertaining to nomenclature:

Dan Pentilla refers to herring as *Clupea pallasi* in his recent reports and yet the species is called *Clupea harengus pallasi* throughout this document.

1. Question: Has the name changed recently?

    RESPONSE: Unless the name has changed in the last year, the correct name is Clupea harengus pallasi. I have seen Dan refer to this species both ways.

<u>From the full text review- referring to page 19 paragraph labeled</u> <u>Ecological Role:</u>

1. I do not know what the numbers in parentheses mean (63 FR 31693)?

    RESPONSE: This is a reference to the Federal Register where information was cited.

Document 3: *Biological Resources Report, Phase 2. September 2001*

Coordinator's Summary

The individual peer reviewer examined the entire technical document and provided comments throughout. The report was "well written" and adequately summarized information for several species (e.g., geoduck, Dungeness crab, marine mammals, and forage fish). The reviewer recognized the author's assessment that "geoduck surveys are out-of-date and additional data are needed." The conclusions for the Dungeness crab section are "weak" because distribution and abundance data are lacking for the species within the siting area. Limited data were provided for red rock crabs.

Three fish species were discussed in the forage fish section, but life history summaries were provided for only two species. Reference should be made to the Phase 1 [*King County Marine Habitat Report*] report containing this third life history description, or the third life history summary provided in this document. Spawning surveys for forage fish were also presented; however, the "site selection for the study [should have been] explained in greater detail," (e.g., reasons why sample stations clustered in the northern vs. southern study locations). Any modification to "standard procedure[s]" should be explained. Results of the forage fish spawning survey "suggest[ed] widespread spawning…within the study area" and that "there appear[ed] to be differences in egg abundance among sites." The reviewer noted a "qualitative survey was a scientifically sound first step [for identifying forage fish spawning areas]," but a quantitative survey "would determine if there are significant statistical differences in egg density within these remaining potential outfall zones."

The data on marine mammals and birds "are nicely summarized in tables and maps." In addition, sections were "well written" and "provide[d] valuable information on sub-estuaries" as habitat for juvenile and adult salmon, as well as other marine species. Lastly, the reviewer commented on the importance of identifying, mapping, and describing "sensitive sites … when considering a suitable outfall location."

The food web section contained information "too general" to adequately describe species relationships. In fact, the reviewer was unclear "what the intent was meant to be" and if the information presented is even "useful in siting an outfall." Goals should be clarified to recognize only general descriptions, or "species-specific food webs need to be developed."

Finally, the reviewer commented that in Figures 2-4 and 2-7 the forage fish spawning survey dates do not correspond exactly to those mentioned in the text.

Recommendations: 1) Collect additional data on Dungeness crab distribution and abundance in the outfall siting areas; 2) instead of species-specific food webs, "it might be more useful to describe the seasonal changes in species composition, abundance and distribution for dominant phytoplankton, zooplankton and benthic organisms within the potential outfall zones;" and 3) section 4.5.1 should contain "some mention of benthic-pelagic coupling."

Document 3: *Biological Resources Report, Phase 2. September 2001*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Review Date: February 7, 2003
Reviewer Name: **Aimee A. Keller**
Technical Document being reviewed: **Biological Resources Report, Phase 2**

General Comments: This report is a supplemental report designed to provide information on additional species of interest within the Brightwater Marine Outfall Siting area. In additional the report documents the presence of biological refuges and restoration sites in the study area. The final topic covered in the document is food web relationships for species of interest in the siting area. The report is well written and does a good job of summarizing information on species not covered in the phase 1 document. In addition to summarizing information on commercially important species such as geoduck and Dungeness crab, the report provides added information on marine mammals and forage fishes. As noted in the report the geoduck surveys are out-of-date and additional data are needed to adequately assess potential impacts on geoducks in the siting area. A subsequent geoduck survey was undertaken to address these concerns and will be reviewed separately (King County 2002). Very little data are available on Dungeness crab distributions and abundance within the siting area. The conclusions for this section are weak and given the commercial and recreational importance of this species additional data on distribution and abundance are required. Perhaps catch record cards could be utilized to determine recreational catch in recent years. If commercial data are only available for a larger area encompassing the potential Brightwater outfall sites then these data should be shown. Red rock crabs are also mentioned but little information about abundance and distribution is given.

The forage fish section begins with a discussion of the three dominant forage fish species in Puget Sound but presents life history summaries for only two of the three species (sand lance and surf smelt). Since life history summaries for all three species were included in the King County Habitat Report (King County 2001), either the phase 2 document should refer to the initial report for all three species or include a summary for herring within the current report. In addition to presenting the life history summaries, the current document presents the results of a forage fish spawning survey undertaken by King County to address a major data gap uncovered in the initial report. The site selection for the study needs to be explained in greater detail. I believe that the stations were clustered in the northern portion of the study area because there are few suitable spawning beaches throughout the remainder of the study area. If suitable sites are located in the southern portion of the potential siting zone than an explanation needs to be given as to why these sites were not surveyed. The methods do not mention that the sediment was sieved prior to winnowing, a standard step in the Penttila procedure (Moulton and Penttila 2001). If the standard procedure was modified than an explanation should be included describing why the modification was undertaken. The results of the study suggest widespread spawning by forage fish at suitable sites within the study area. Based on this qualitative survey, there appear to be differences in egg abundance among sites. Now that the list of potential outfall sites has been narrowed to three candidates, perhaps additional data should be collected to determine if there are significant statistical differences in egg density within these remaining potential outfall zones. Qualitative surveys are important for identifying forage fish spawning areas but a quantitative survey would address differences among the remaining potential outfall sites. The qualitative survey was a scientifically sound first step using the best available techniques. These techniques were developed particularly for studying forage fish throughout the Puget Sound area.

The section on marine mammals and birds provides information on additional species or additional data on distribution and abundance of species covered in the King County habitat report – phase 1 (King County 2001). The added information will be useful for determining potential impacts to marine mammals and birds within the siting area. Data are nicely summarized in tables and maps. The section on important habitat and protected areas is well written and provides valuable information on sub-estuaries utilized by adult salmon during their spawning migrations and potentially utilized by juvenile salmon and other marine species as nursery and feeding areas. In addition, sites involved in restoration activities and the marine protected areas near Edmonds are mapped and described. Identifying the location of sensitive sites such as these is essential when considering a suitable outfall location.

The information presented in the food web section of the report is too general to accomplish the stated goal of describing key food web relationships for given species. Either the goal has to be restated to acknowledge that only a very general description of trophic interactions will be given or species-specific food webs need to be developed. In most cases the information required for species-specific food webs in unavailable. Many species alter their food sources based on what is seasonally available and very few detailed studies have been undertaken describing the changes in diet, which occur as organisms grow. I am unsure how the information incorporated in this section would be useful in siting the outfall. I am also unsure what the intent was meant to be. It might be more useful to describe the seasonal changes in species composition, abundance and distribution for dominant phytoplankton, zooplankton and benthic organisms within the potential outfall zones; although much of this information appears sparse for Puget Sound in general.

<u>Specific Comments</u>

Page 1, section 1.1, bullet 3 – rewrite – does not make sense as currently worded-Example: Describe key food web relationships for species present in Brightwater Outfall Siting Area

Page 4, section 2.1.1, line 5 delete “and reported”
Same paragraph – final sentence. There must be some way to determine which areas were surveyed with no geoducks present and which were not surveyed?????

Page 10, 1st paragraph – why is the minimum size for Dungeness crab represented as 6/14 inches? Are these sizes really a minimum and a maximum size limit – if so than state properly.

Page 14. Figure 2-4. The legend gives a date range for the forage fish spawning surveys from January 1995 – May 2001; the text that refers to the figure states that surveys were undertaken from Nov. 2000 to February 2001.

Page 15, paragraph 3 ’line 4. Change ‘amounts shell’ to ‘amounts of shell’

Line 7. Change 'number transects' to 'number of transects'

Page 17, line 9. Change 'algaes' to 'algae'. Algae is plural for alga, algaes is not a word.
Line 11, Change 'All these results' to ' Results'

Page 19, Table 2-3. If eggs were found by WDFW then the comment under the egg heading should be "yes" not "no" since they also used the same techniques.

When will the additional results (TBD) be added to this table?

Page 20. Figure 2-7. The dates appear to be incorrect again – legend states Jan 1995 – May 2001 when study was completed from Nov 2000 to Feb 2001.

Page 22. Figure 2-8. I cannot distinguish differences in density based on the legend – was this originally a color figure? I also have the same problem with figure 2-9.

Page 30. Section 2.4.4. Remove blank line after line 4.

Page 52. Section 4.5.1. Sentence 2- The way this sentences is worded implies that temperature will change as a result of biological activity.

Same section, Paragraph 2 – The size ranges that are given for microphytoplankton and nannoplankton are not the generally accepted size ranges (although different people do use different ranges nanoplankton are generally defined as plankton in the 2 – 20 μ size range and microphytoplankton are typically 20 – 200 μ)

Some mention of benthic-pelagic coupling should appear within this section

Page 53. Line 6. The sentence beginning with "These microbes are utilized by viruses" should be reworded since it is implying that viruses eat microbes. I do not think that viruses are generally considered a part of the microbial loop.

Food web figures are inconsistent in their inclusion of taxa within the major food categories – ex. page 61 – the taxa for macroalgae are given in the figure legend but none are given for phytoplankton, even though both subcategories appear in the diagram yet on page 63 taxa for both phytoplankton and macroalgae are listed in the legend, a space is given for microalgae, but no organisms are listed and all 3 groups appear in the diagram.

Page 72. Goodwin and Pease. 1989. Pacific appears as "Pacifi'

Literature Cited

King County. 2001. King County marine habitat report. Prepared in support of the wastewater treatment division habitat conservation plan and the Brightwater Marine outfall siting study. Submitted by Striplin Env. Assoc., Battelle Marine Sciences Lab., and King County DNR.

King County. 2002. Brightwater marine outfall: A geoduck (*Panopea abrupta*) survey for the Brightwater marine outfall. Submitted by Golder Associates Inc. and Parametrix.

Moulton, L.L. and D. Penttila. 2000. Forage fish spawning distributions in San Juan County and protocols for sampling intertidal and nearshore regions. Final report. San Juan County Forage Fish Assessment Project. Marine resources Committee, san Juan County, Friday Harbor, WA.

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

Responses provided by Kim Stark, King County DNR

From the full text review- referring to Section 2.1.1 (page 4):

1. "There must be some way to determine which areas were surveyed with no geoducks present and which were not surveyed?"

> *RESPONSE: Agree. This could have been determined with effort, however, the intent of this section was to provide existing information on known geoduck abundance in the Brightwater area and included information from surveyed areas only.*

From the full text review- referring to Section 2.1.1 (page 10):

1. "Why is the minimum size for Dungeness crab represented as 6/14 inches? Are these really a minimum and a maximum size limit – if so than state properly?"

> *RESPONSE: This is a typo--the minimum legal harvest size is 6-1/4 inches.*

From the full text review- referring to Table 2-3 (page 19):

1. "When will the additional results (TBD) be added to this table?"

> *RESPONSE: Unfortunately never. Extra samples were taken with the hope of analyzing them at a later date but staffing resources did not allow for those samples to be analyzed and they have since been disposed of.*

From the full text review- referring to Figure 2-8, 2-9 (page 22):

1. "I cannot distinguish differences in density based on the legend – was this originally a color figure?"

> *RESPONSE: Yes.*

Document 4: *Brightwater Marine Outfall Phase 3 Biological Resources Report. November 2002*

Coordinator's Summary

Both peer reviewers examined the entire technical document, and provided comments independently.

Aimee Keller: Biological comments

Comments were generated for three main technical sections: forage fish spawning habitat data, juvenile salmonids and marine finfish distribution and abundance, and a literature review for spot prawns.

First, the reviewer concentrated on the forage fish survey data and the reporting of the updated data in document tables. Specifically, "the inclusion of the updated data from 2000-2001 is obvious given the change in status for Richmond Beach County Park between the phase 2 and phase 3 documents." Documented spawning habitat for sand lance and surf smelt was not observed during phase 2, only the phase 3 studies. This "change in status should be acknowledged by stating that samples designated as TBD (to be determined) in table 2.3 of the phase 2 document were sorted in the interim and the results incorporated in the current assessment."

The sampling methodology for juvenile salmonids and finfish was appropriate although the sample design should have been covered more thoroughly. "The rationale for the selected experimental design should be stated, i.e., station location, number of locations and sampling frequency." The sampling technique was explained thoroughly, and the equipment and protocols were appropriate for the target species (i.e., seining juvenile salmonids). The difference between "whole fish" and "stomach" samples should have been described in the methods; however, the reviewer questioned the need for distinguishing between the two because "the entire contents of stomachs" are examined in both cases, versus the lavage method where some contents go undetected. Also, mortality rates associated with the gastric lavage sampling technique should have been listed. The reviewer stressed the importance of thorough and comprehensive analyses of the forthcoming final results to "minimize impacts to listed salmon species" when selecting a suitable outfall location.

A comprehensive literature review was conducted for spot prawns. Obtaining annual test fishery data and catch data from the previous decade would "provide some insight into long-term changes in adult spot prawn abundance in the outfall area." Further, "if monthly data are available then seasonal abundance could also be examined."

Recommendations: 1) "a quantitative study would help determine if differences in [forage fish] egg density are significant between the remaining candidate sites," 2) the juvenile salmonid and marine finfish stomach content analysis "should be utilized to improve the food web discussion in the phase 2 [biological resources] document," 3) "the location of known spot prawn beds should be compared to sediment type to determine adult habitat requirements," 4) "the data gaps on larval abundance and distribution could be addressed with an ichthyoplankton and/or zooplankton survey, another data gap identified in a prior report," and 5) a collaborative study to address the existing data gaps may benefit the fishery resource managers and the outfall siting process.

Mike Connor: Ecological comments

The reviewer expressed some difficulty evaluating the utility of this document without reading and considering the Habitat Conservation Plan (HCP), of which this document "purport[s] to support." The document lacked "an overall context within Puget Sound in which to place the information." Thus, the reviewer felt it was difficult to comment on the importance of the document's findings in relation to the "overall health of these species." Specific comments were directed at sampling procedures. For example, some fish were miscounted therefore "it would be useful to flag those samples and estimate how many fish were missed."

Recommendations: None

Document 4: *Brightwater Marine Outfall Phase 3 Biological Resources Report. November 2002*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Review Date: February 10, 2003
Reviewer Name: Aimee A. Keller
Technical Document being reviewed: **Brightwater marine Outfall Phase 3 Biological Resources Report**

General Comments

The phase 3 biological resources report is designed to address data gaps uncovered in the phase 1 and phase 2 documents (King County 2001a, King County 2001b). The report describes two research projects undertaken to characterize: 1) forage fish spawning habitat; and 2) distribution and abundance of juvenile salmonids and other marine finfish in the candidate outfall areas. In addition, a literature review describing distribution, habitat requirements, life history and fisheries for spot prawns, a commercially important invertebrate species, is included in the phase 3 document.

The forage fish study utilizes the qualitative techniques described in the phase 2 document (King County 2001) but focuses on additional stations near the most likely candidate sites for the Brightwater outfall (Sites 6, 7N and 7S). Three new areas were surveyed for forage fish spawning activity in 2001-2002; in addition, the results from the 2000-2001 survey were updated and incorporated in a table summarizing the documented spawning habitat sites (table 2-2). The inclusion of the updated data from 2000-2001 is obvious given the change in status for Richmond Beach County Park between the phase 2 and phase 3 documents. However, the change in status should be acknowledged by stating that samples designated as TBD (to be determined) in table 2.3 of the phase 2 document were sorted in the interim and the results incorporated in the current assessment. The qualitative results from the 2001-2002 survey confirm the widespread presence of spawning habitat within the candidate outfall zones. A quantitative study would help determine if differences in egg density are significant between the remaining candidate sites.

The juvenile salmonid and marine finfish study presents preliminary results for a nearshore beach seining study. A pilot study was undertaken in 2000 to determine sampling logistics and establish a nearshore fish catch baseline database. No baseline data are presented but presumably will appear in a separate report, which is noted to be in preparation. How the sampling logistics were established is also not discussed but based on the 2000 study, a series of stations were selected and sampled in 2001. The rationale for the selected experimental design should be stated, i.e. station location, number of stations and sampling frequency. A thorough description of the sampling technique was given. The beach seine used in the study was the standard size recommended for collecting juvenile salmonids in Puget Sound. The accepted protocols for sampling juvenile salmonids were carefully followed. A subset of fish were measured and salmonids were examined for the presence of fin clips and Coded Wire Tags (CWT). Three techniques were utilized to retain stomach contents: whole fish, stomachs and gastric lavage. The goal of gastric lavage is to obtain the stomach contents without killing the fish, a particularly important consideration when working with threatened species, such as Puget Sound chinook. The technique is difficult to perform properly and the mortality rate associated with the procedure should be noted. An explanation of the distinction between whole fish and 'stomach' should be given somewhere in the methods. I assume that in some cases the stomach was dissected from the fish and returned to the laboratory for examination while in other cases the entire fish was preserved for analysis. I am not sure why this distinction is being made since in both cases the entire contents of the stomachs will be examined as opposed to the lavage method where some portion of the contents can be missed. The preliminary results are summarized in a series of tables. A statistical analysis is forthcoming. The methods are appropriate but the sample design needs to be presented in a more complete fashion. The results will be critical in selecting the most appropriate site to minimize impacts to listed salmon species. This is a very important study to the siting procedure and needs to be carefully analyzed by a competent statistician when the final results are available. The stomach content analysis should be utilized to improve the food web discussion in the phase 2 document (King County 2001b).

The literature review for spot prawns is thorough and complete. Some effort should be made to obtain the annual test fishery data and the catch data (commercial and recreational) over the past 10 years. These data would provide some insight into long-term changes in adult spot prawn abundance in the candidate outfall area. If monthly data are available then seasonal abundance could also be examined. The location of known spot prawn beds should be compared to sediment type to determine adult habitat requirements. The section on data gaps clearly identifies that additional research is required on both larval and juvenile distribution and abundance patterns in the siting area. The data gaps on larval abundance and distribution could be addressed with an ichthyoplankton and/or zooplankton survey, another data gap identified in a prior report. It is difficult to understand how the spot prawn fishery can be properly managed given the existing data gaps. Perhaps a collaborative study would benefit the managers of the fishery and the siting procedure.

Specific Comments

Executive Summary – 1st page, final line. Either the total number of chinook should be mentioned or the percent with coded wire tags should be stated if the goal is to compare the number with CWT to the number ad-clipped. 2nd page, final paragraph, line 9 'usually' is misspelled. Line 12 reword the section on minimum length of prawns since the current wording suggests that the traps have a minimum size, rather than the shrimp.

Page 6, paragraph 2, line 9 – delete a in the phrase 'within a five days'

Page 7, paragraph 3, line 1 – delete the in the phrase 'at the Brackett's Landing'

Page 7, paragraph 7, line 1 – delete 'Surf smelt and sand lance spawning habitat for the' and begin with 'Forage fish spawning…

Page 11, section 3.1, 1st paragraph, line 7 – I am not sure what is meant by the phrase 'prey production functions'
Page 12, section 3.3.1 line 8 – provide an explanation of the phrase 'non-overlapping sets' – when it first appears here in the methods

Page 15, paragraph 2, line 4. MS-222 should be written out as tricaine methanosulfate since not all readers will be familiar with this substance.

Page 16 section 3.4, line 5 change 'over 40 individual species' to '43 species or species groups'

Page 19, 1st sentence after bullets. Explain why current hatchery practices make it difficult to determine point of release – why would fish marked for release at a specific location be released elsewhere. If this is true then something is very wrong with the marking procedure.

Page 21, section 3.4.3, final line – this is the first mention of samples for 2002, perhaps they should be mentioned earlier when referring to the upcoming report

Page 25, 1st paragraph, line 4 – insert a space after deep(WDFW,

Page 25, Section 4.2, paragraph 2, line 4 change 'The life span of spot prawns is in' to 'The life span of spot prawns in'

Page 26, paragraph 3, line 15 Districts is misspelled as Disctricts

Page 27, Figure 4-2 – Candidate outfall zones are not shown on the figure

Page 29, References: Healy 1980 and Healey 1982 refer to the same citation but the names and the dates are different, as is the format used for the citation. The date and spelling need to be corrected. The citation on page 11 is Healy 1982 in paragraph 1 and Healy 1980 in paragraph 2

Literature Cited

King County. 2001a. King County marine habitat report. Prepared in support of the wastewater treatment division habitat conservation plan and the Brightwater Marine outfall siting study. Submitted by Striplin Env. Assoc., Battelle Marine Sciences Lab., and King County DNR.

King County. 2001b. Brightwater siting project marine outfall siting study – phase 2: biological resources report. Submitted by Striplin Env. Assoc. and Parametrix.

END OF KELLER FULL TEXT REVIEW

Puget Sound Peer Review

Reviewer: Mike Connor

Document	Brightwater Marine Outfall Phase 3 Biological Resources Report
General Comments	This report provides additional information on biological resources in the Marine Outfall Siting Area. It complements a Phase 2 report that I read, but did not formally review. These reports purport to support the preparation of a Habitat Conservation Plan (HCP), and it is hard to evaluate their usefulness without seeing the HCP. In general, the reports lack an overall context within Puget Sound in which to place the information. We can say that sand lance and surf smelt spawning habitat exists along beaches in the area of the outfalls, salmon can be found in some parts of the year, and spot prawn beds are found in outfall zone 6 and 7s. It is hard to say much about the significance of these findings to the overall health of these species. I presume the results will fit into some overall assessment methodology for the HCP.
Specific Comments	
Sec. 2.1, p.4	Training was in accordance with WDFW methodology. Is there some sort of certification or split sampling to verify compliance with these methods?
Sec. 3.3.2, p.13	How were the fish chosen for length measurements? Is the sample random? I would guess if the first ten fish were measured that the sample would be biased for longer fish. In some instances, the fish were not completely counted. It would be useful to flag those samples and estimate how many fish were missed.
Sec. 3.4, p.16	The fish length data are not presented, and I could find no explanation.
Summary	Without the context of the HCP, I cannot summarize whether this report supports the findings of the HCP.

END OF CONNOR FULL TEXT REVIEW

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

Aimee Keller

From the full text review- referring to Page 19:

1. Explain why current hatchery practices make it difficult to determine point of release – why would fish marked for release at a specific location be released elsewhere? If this is true then something is very wrong with the marking procedure.

Respondent: Jim Brennan

> *RESPONSE: Staff have heard different reports from various sources that when hatcheries have left over fish they give them to other non governmental groups to plant where they want as long as WDFW approves. Sometimes they give out CWT fish to the various groups, and CWT fish get planted in places not recorded. This presents some degree of uncertainty about the timing and points of release. It would be a huge task to accurately track all practices, so we simply added a caveat in our report to be clear that some level of uncertainty exists. I fully agree that there is something seriously wrong with hatchery release practices if tags do not accurately reflect time and point of release.*

Mike Connor

From the full text review- referring to Section 2.1 (page 4):

1. Training was in accordance with WDFW methodology. Is there some sort of certification or split sampling to verify compliance with these methods?

Respondent: Kim Stark, King County DNR

> *RESPONSE: There is no certification but there was split sampling and egg identifications by King County staff in 2001 (the Phase 2 sampling) were verified by Dan Penttila at WDFW.*

From the full text review- referring to Section 3.3.2 (page 13):

1. How were the fish chosen for length measurements?
2. Is the sample random?

Respondent: Jim Brennan

> *RESPONSE: I wasn't out that much in 2001, but I don't think fish (salmonids) were being "separated" very frequently. The protocols called for a random subsample (if a subsample was needed). Otherwise, all salmonids were supposed to be measured. All salmonids were not measured (unfortunately), but I believe that the samples measured*

are fairly "random" and are a good representation of the species captured. Therefore, for 2001, I think it is reasonable to say that fish were sampled randomly. Whatever inconsistencies there were in 2001 were resolved in 2002 and I have great confidence in our 2002 data.

To be more specific about "how fish were chosen", we could add some language that describes how fish were taken from the "bag" in the beach seine and placed in fresh seawater for transport to the processing station on the beach. Individual fish were pulled from the buckets and measured, with no intentional selection for specific sizes, until at least 10 fish of an individual species were measured. This became the subsample. All species were supposed to be identified and enumerated. However, there were some problems with this, as described in section 3.3.2. Again, I believe we resolved these issues in 2002.

Document 5: *King County Nearshore Habitat Mapping Data Report: Picnic Point to Shilshole Marina. March 2001*

Coordinator's Summary

Both panel members reviewed the entire technical document, independently, and agreed that the document was organized and well written, presented an excellent study design, contained quality datasets, and utilized equipment that was appropriate for the study.

Aimee Keller: Biological comments

The measurement methods used for evaluating and mapping the nearshore habitat were "powerful" and "state-of-the-art." The reviewer validated the author's conclusion that the measurement methods were not suitable for assessing geoduck abundance. Side scan sonar and underwater video allowed for exceptional coverage of the study area. The variables selected for study were adequate to describe nearshore habitat "and provide a baseline reference against which future impacts could be assessed." The reviewer questioned the timing of eelgrass surveys as outlined in the experimental design, though acknowledged the author's for recognizing these surveys should occur earlier in the calendar year.

Recommendations: Data should be further analyzed since the number of outfall sites has been reduced to three. Specifically, "fisheries resources and macroinvertebrates should be mapped in reference to the candidate outfall zones to make the results of the mapping study readily useful to decision makers and managers." In addition, an extra summer survey for *Ulva* in the final candidate outfall zones, or repeated diver surveys along the same tracts may be warranted in order to expand seasonal coverage, or address variations in "seasonal occurrence of vegetation," respectively.

Doug Levin: Geological (mapping) comments

An exceptional nearshore habitat study that incorporated comprehensive data collection and data processing methods, justifiable statistical applications, and thorough, descriptive reporting in each section of the document. The reviewer recognized the author's attempt to complete a literature review to assist with the study design and analysis of data. Further, the document contained a substantial quantity of "well-founded scientific information" concerning the outfall zones, and "appears to be a valuable 'keystone' study on which others should be modeled."

Side scan sonar and videography were appropriate tools to produce "accurate, georeferenced maps of benthic habitat," an objective of the study. "Tow speeds for both the side scan and video collection were optimum." Report figures were of high quality, displaying superb detail and "precise transfer of coordinate information from the side scan sonar and video data to a GIS resource." Comprehensive QA/QC procedures ensured that the data were "treated appropriately and not pushed for information that could not be supported statistically and scientifically." No Recommendations.

Document 5: *King County Nearshore Habitat Mapping Data Report: Picnic Point to Shilshole Marina. March 2001*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Review Date: February 16, 2003
Reviewer Name: **Aimee A. Keller**
Technical Document being reviewed: King County nearshore habitat mapping data report: Picnic Point to Shilshole Marina

General Comments: The objective of this study was to produce accurate, georeferenced maps of benthic habitats and fisheries resources along ~22 km of shoreline in east Puget Sound. The primary emphasis of the study was a detailed description of the methods, as well as presentation of maps and summary tables. The primary categories mapped and summarized were substrate, vegetation, fish and macroinvertebrates. Each of the habitat types was further subdivided into additional categories. For example, substrate could be classified as natural (sand, gravel, rock etc.) or artificial (logs, wood debris, crab pots etc.) and percent cover could be determined for each substrate type. Vegetation was subdivided into eelgrass, kelp or macroalgae with percent cover assessed for each variable. Sufficient variables were selected for study to characterize the nearshore habitat and provide a baseline reference against which future impacts could be assessed.

Measurement methods were a combination of side scan sonar, underwater videography and diver survey. The method proved to be a powerful, state-of-the-art technique appropriate for assessment and mapping of nearshore habitat in Puget Sound. As noted by the authors, the technique was not appropriate for surveying geoduck abundance but worked well for the other variables included in the study. Several suggestions were made to streamline the process and make it more cost effective.

The sample design consisted of collecting data along tracts parallel and perpendicular to shore from –30 m MLLW to the shoreline. The experimental design provided excellent spatial coverage of the study area via side scan sonar and underwater video. Very little of the survey area was groundtruthed by diver survey. However, the underwater video technique verified the side scan sonar findings in a comprehensive fashion. My only criticism of the experimental design is the timing of the survey, which took place from October to mid-November. As noted by the authors, the optimal time for eelgrass surveys is somewhat earlier in the year (1 June to 1 October) prior to the end of the growing season and the occurrence of storms that tend to thin the coverage.

As stated by the authors, the goals of the study were to accurately describe the methods and make the results available for future analyses. Consequently, data analysis was not considered a goal for the current report. A portion of the data (submerged aquatic vegetation) has since been analyzed (King County 2001) but additional analyses should be undertaken now that the number of candidate sites has been reduced to the final three. In particular, fisheries resources and macroinvertebrates should be mapped in reference to the candidate outfall zones to make the results of the mapping study readily useful to decision makers and managers. At the time the report was prepared, the potential outfall sites were still undecided.

Specific comments

Page ix. Table 11. Zostera marina should be italicized as *Zostera marina*

Page 8, Paragraph 2, line 11. Change 'data was' to 'data were'

Page 11, Paragraph 2, line 1. Change 'data was' to 'data were'

Page 15, Section 2.2.1.1. Line 3. Change 'this data was' to 'these data were'
Line 6. Change 'track line file of data' to ' track line data file'

Page 16, Paragraph 3, line 7. Change 'data that was' to 'data that were'

Page 17, **Eelgrass** paragraph, line 2. Change 'used in Chesapeake' to 'developed in Chesapeake'
Line 3. Change 'this method estimates' to 'this method is used to estimate'

Page 23, Table 9, section on non-schooling fish. Add *Scorpaenichthys marmoratus* after the or in the line for Loc Lingcod or Cabezon
Also: the family names given in the table should not be italicized ex. Embiotocidae, Bothidae, Pleuronectidae. And the spp. after both *Hexagrammos* and *Raja* should not be italicized

Page 24. Table 10. The sp. after *Urticina* and *Cancer* should not be italicized

Page 25, paragraph 2, line 5 change *Ulva spp.* to *Ulva* spp.

Page 30-31. The number of perpendicular tracks listed in Table 13 do not appear to match the number shown in the Figure 5. Example - in subarea D there appear to be 2 track lines in Figure 5, while 3 are listed in the Table 13.

Page 33, Paragraph 2, line 1. Change 'data was' to 'data were'

Page 39, Paragraph 2, line 6. Change 'track line data for dominant substrate is' to 'track line data for dominant substrate are'

Page 59, line 1. Change 'presence and density was' to 'presence and density were'
Line 5. Change 'data for each area is' to 'data for each area are'

Page 60, Table 18. Total *Ulva* in the dense category is listed as 0% – I think that it should be <1% since a value is shown in Area A

Page 64, Table 21. I wondered why there are so many juvenile seas pens (158,762-292,373) and so few adults (96)– why such a high mortality between the juvenile and adult stages? Also *Utricina* should be italicized in the Table.

Page 65, line 6-7. Change '*Ulva spp.*' to *Ulva* spp.' (The spp. should not be italicized)
Page 68, line 1. I sincerely hope that plans are underway to fully analyze this wonderful dataset.

Page 69, Paragraph 2, line 1-2. Change 'and 12 areas, and found' to 'and 12 areas, and was found'????? I think. Also change 'It' at the start of the next sentence to 'Kelp'

Page 70. Line 3. Change 'associated with it' to 'associated with them'

Page 70, Paragraph 2, line 1. Change 'Its presence' to 'Their presence';
Line 4. Change 'for this reason,was sometimes difficult to assign' to 'for this reason we sometimes had difficulty assigning'
Line 5. Change 'Oct' to 'Oct.'
Also: The point is made at the end of the paragraph that *Ulva* may have been reduced in abundance relative to what was present earlier in the season. Perhaps an additional survey needs to be undertaken during summer with emphasis focused on the reduced number of candidate outfall zones – this would have the advantage of increasing the seasonal coverage as well as focusing attention on the final sites under consideration. However, perhaps the differences in seasonal occurrence of vegetation could be addressed in a more cost-effective fashion by simply repeating the diver survey along the same tracts done in Oct-Nov, throughout the summer.

Page 70, final paragraph. I was unsure which species were being referred to at the beginning of the 2nd sentence – schooling species or tubesnout and shiner surfperch'? Please clarify.

Page 73, Paragraph 2, line 1. Change 'specie' to species'

Page 74. Line 1. Change 'data does' to 'data do'

Page 76, bullet 3, line 2. Change 'thevideo' to 'the video'

Page 79. Be consistent in the use of pp. It appears as pp. in the 1st citation and Pp. in the 6th. Also I am not sure why quotations are used in the 3rd citation but not in any of the others.

Appendix E, Page E-1. I do not know what the e? in the first row of the table means.

Appendix H. Cover Page. Change '*N. Luetkeana* and *S. Muticum*' to '*N. luetkeana* and *S. muticum*'- no caps in the specific

Conclusion: This is a very nice report – additional analyses (similar to those done for submerged aquatic vegetation) should be undertaken to take advantage of the quality data produced.

Literature Cited
King County. 2001. Submerged aquatic vegetation patterns in candidate outfall zones. Submitted by Parametrix.
END OF KELLER FULL TEXT REVIEW

Report Reviewed- King County Nearshore Habitat Mapping Data Report: Picnic Point to Shilshole Marina

February 20, 2003

Douglas R. Levin, Ph.D.
Geologist for Marine Outfall Siting Study (MOSS) Peer Review
BrightWater Marine Outfall Siting Study

Summary

This evaluation is offered in the spirit in which it was assigned to the Puget Sound Marine Outfall – Formal Peer Review Panel. The comments are offered without the benefit of seeing the specifications requested of Batelle Marine Sciences Laboratory, Sequim, Washington prior to conducting the investigation for the King County Department of Natural Resources.

1. Were the studies designed appropriately, with sufficient data to satisfy the objective(s)?

This was an excellent study of the nearshore habitat. There was a noted effort to conduct a literature review to help design the study and assist in the data analysis.
The equipment selected to collect the data was adequate. The data processing methodology was detailed and thorough. Statistical applications used to present the findings were well founded. The report is organized and well written.

Review the following for additional and more detailed comments.

King County Nearshore Habitat Mapping Data Report: Picnic Point to Shilshole Marina

Woodruff, et al, March 2001

Report Comments:

Overall, this is an excellent report that contains a great deal of well-founded scientific information about the candidate outfall areas. The data was collected using a thoughtful and thorough design. The detailed coverage of the nearshore area appears complete. This appears to be a valuable "keystone" study on which others should be modeled.

I will comment on the mapping aspect of the program. The biologic comments will be tendered by a professional from that field of study.

1.1 Objective

The objective to provide accurate, georeferenced maps of benthic habitat in the study area was met. The use of side scan sonar and videography was a correct application of the complementary tools. Creating GIS compatible maps from this information allowed all parties with GIS capabilities to take advantage of these data resources. The study created 6 sets of deliverables for King County, as detailed on p. 2 of this report.

1.2 Study Area

The study area was clearly described and depicted in Figure 2, following p. 4.

--- What was the rationale for dividing the study area into twelve discrete areas?

2.1 Field Collection

The equipment description was clear and concise.

--- In either field collection or analysis there is no mention of whether the DGPS data was post processed to increase position accuracy.

----The frequencies used for the dual frequency side scan sonar was not mentioned. Were both frequencies recorded simultaneously? or, which frequency was selected?

---- The altitude of the side scan towfish during data acquisition was not discussed. It should have stayed at 10 – 20% of the range. Seeing as the water depths were so shallow, this probably wasn't an issue.

2.1.3 Underwater Video Data Collection

p.9 "The track lines were parallel to and 15 m shoreward of the side scan track lines."

---- This is one of the few unclear sentences in this report. Is the translation that the track lines were offset 15 m to avoid collecting video in the acoustic nadir of the side scan system?

Tow speeds for both the side scan and video collection were optimum.

2.2 Data Analysis

The QA/QC was detailed and provided a high level of confidence that the data was treated appropriately and not pushed for information that could not be supported statistically and scientifically. Literature was reviewed to determine whether applicable methodologies, like the Crown Density Scale (Paine 1981) could be used in the Data Analysis. Dethier's work (1990), Marine and Estuarine Habitat Classification System for Washington State, was also consulted.

3.0 Results

The results section was thorough and detailed. Figures 7 through 16 provided excellent illustrations of how the bottom types were classified. The subsequent figures, reductions of the full size plates, showed excellent detail and a precise transfer of coordinate information from the side scan sonar and video data to a GIS resource.

Position accuracy problems were recognized and effectively justified by addressing possible error contributions (for example, p. 67).

4.0 Discussion

The discussion was thorough and well written.

5.0 Conclusions

This was a well designed and executed program. The conclusions offer refinements and recommendations for improving on the work that they did. It is unclear whether follow-on programs, such as the SAV mapping program, considered this list of suggestions.

References (For this document)

Dethier, M.N., 1990. A Marine and Estuarine Habitat Classification System for Washington State. Washington Natural Heritage Program. Dept. of Natural Resources. 56pp. Olympia, Washington.

Paine, D.P., (1981) Aerial Photography and Image Interpretation for Resource Management. John Wiley & Sons, Inc. New York City, New York. 571 pp.

END OF LEVIN FULL TEXT REVIEW

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

--NOT PROVIDED FOR THIS TECHNICAL DOCUMENT--

Aimee Keller

Table 21 (page 64):

2. I wondered why there are so many juvenile seas pens (158,762-292,373) and so few adults (96)- why such a high mortality between the juvenile and adult stages?

Section 4.0, Discussion (page 70):

C. I was unsure which species were being referred to at the beginning of the 2nd sentence – schooling species or tubesnout and shiner surfperch'? Please clarify.

Appendix E (page E-1):

1. I do not know what the e? in the first row of the table means.

Doug Levin

Section 1.2, Study Area:

1. What was the rationale for dividing the study area into twelve discrete units?

Section 2.1, Field Collection:

1. The frequencies used for the dual frequency side scan sonar was not mentioned. Were both frequencies recorded simultaneously? Which frequency was selected?

Section 2.1.3, Underwater Video Data Collection:

"The track lines were parallel to and 15 m shoreward of the side scan track lines."

1. This is one of the few unclear sentences in this report. Is the translation that the track lines were offset 15 m to avoid collecting video in the acoustic nadir of the side scan system?

Document 6: *Submerged Aquatic Vegetation Patterns in Candidate Outfall Zones. September 2001*

Coordinator's Summary

Both panel members reviewed the entire technical document, and provided comments independently. The report, *Submerged Aquatic Vegetation Patterns in Candidate Outfall Zones*, described the results of sampling methods to determine the patterns and abundance of submerged aquatic vegetation within the candidate outfall zones.

Aimee Keller: Biology comments

The reviewer acknowledged the importance of eelgrass and kelp beds as habitat for juvenile salmonids, including listed species in Puget Sound. The variables measured in the study were "appropriate," however some were not explained. For example, eelgrass was subdivided into percent cover categories but kelp was not, and "no specific mention was made of how eelgrass and kelp were distinguished."

Next, the methods were "scientifically sound" and "represent[ed] state-of-the-art measurements." Survey coverage of the nearshore areas and "overlap along transects" within each candidate outfall zone was comprehensive. The reviewer noted a "somewhat subjective" approach when "setting the boundaries between different eelgrass densities at high to moderate densities." Lastly, "potential cross-shelf openings," or pathways, were clearly identified and mapped.

The sample design was comprehensive. Surveys were performed during the fall and spring of different years, though no explanation of why was provided in the report. The reason should be noted, as well as if the spring-fall period captured "the greatest seasonal extent of submerged aquatic vegetation." Finally, with the exception of some difficulty differentiating color patterns, the results "were analyzed and presented in an easy to interpret fashion."

Doug Levin: Geological (mapping) comments

The data appeared sufficient to satisfy and "answer the objectives posed by the DEQ's." Provided the main objective was to identify "corridors crossing the SAV beds," the "relevant data was considered." However, because the "report [was] unfocused, poorly written, and use[d] terms incorrectly and inconsistently," the "scientific merit within [was] difficult to assess."

For example, in the Field Methods section it was unclear "whether additional data was collected to supplement the SAV Pattern analysis." Also, the "spatial overlap" of data between zones was not illustrated in any of the figures (as referenced in the document). The reviewer noted additional problems in the Data Analysis Methods and Results section. In particular, context was not provided for cover class resolution, cover class terminology was inconsistent and not cited (from Woodruff et al, 2001), and it was "unclear whether [recommendations from Woodruff et al, 2001] were used to further this program's objective(s)." In addition, "determin[ing] how to handle a data set" should be determined prior to data collection, and units of measurement should not be mixed (e.g., SAE and metric).

Lastly, the reviewer commented generally on Figures. For example, "the shoreline [was] difficult to reference to the water, and the contours [were] not labeled and minor contours difficult to see." Also, "the shape of the moderate eelgrass [was] suspiciously geometric compared to the nearshore bed shapes."

Document 6: *Submerged Aquatic Vegetation Patterns in Candidate Outfall Zones. September 2001*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Review Date: February 5, 2003
Reviewer Name: **Aimee A. Keller**
Technical Document being reviewed: **Submerged aquatic vegetation patterns in candidate outfall zones**

General Comments: This report describes the results of a hydroacoustic and videographic assessment of submerged aquatic vegetation in the vicinity of eight candidate zones for a new marine outfall to be located in Puget Sound. The goal of the research was to describe the patterns and abundance of submerged aquatic vegetation within the proposed candidate outfall areas. The research is particularly important since eelgrass and kelp beds provide important habitat for juvenile salmonids, including species currently listed as threatened in Puget Sound. One approach currently under consideration for construction of the outfall would involve cut-and-cover techniques through the nearshore zone. The data collected during the survey provide the information needed to judge where the outfall could be sited to minimize the impacts to submerged aquatic vegetation. My general comments are subdivided into four categories: variables measured, measurement methods, sample design, and data analysis.

Variables measured – The report was designed to answer two questions: 1) what is the impact on eelgrass beds of constructing the marine outfall; and 2) what is the impact on kelp beds of constructing the marine outfall. The variable measured was the percent coverage of submerged aquatic vegetation within the nearshore zone of each candidate outfall area. For eelgrass beds, four categories of percent cover were distinguished: 1) dense (85-100% cover); 2) moderate (50-85% cover); 3) sparse (10-50% cover); and none to sparse (0-10% cover). The longshore extent of an eelgrass patch was also factored into the classification scheme used to describe eelgrass beds from dense to 'none to sparse'. Kelp beds were also plotted on maps but were not similarly subdivided into categories. Some explanation should be provided for the differential treatment of the two categories of submerged aquatic vegetation. It was noted that video data were used to compute percent cover of submerged aquatic vegetation and to enumerate other marine invertebrates and fish species. No specific mention was made of how eelgrass and kelp were distinguished, although presumably this was done using the video as well. This should be clearly stated.

Measurement methods – Measurements were made using a combination of side-scan sonar and underwater video. The video data were used to ground-truth the side-scan sonar (hydroacoustic) measurements. The techniques used are scientifically sound and represent state-of-the-art measurements. The data were used to create GIS layers showing density and type of submerged aquatic vegetation. The vegetative layers were added to maps showing the 8 candidate outfall zones. The area surveyed provided comprehensive coverage of the nearshore area from +1 to –30 meters mean lower low water within each potential outfall zone. The technique is somewhat subjective in setting the boundaries between different eelgrass densities at high to moderate densities. The location of cross-shelf areas with a classification of 'none to sparse' was less subjective. The authors clearly identified pathways that ran perpendicular to the shore with a classification of 'none to sparse' and a width greater than 25 feet as potential cross-shelf openings. Results indicated that in all candidate outfall zones where an aquatic vegetation corridor was present it was greater than 100 feet wide. Such areas would be the potential pathways for siting an outfall to minimize the impact on submerged aquatic vegetation. The locations of these cross-shelf pathways are identified on geo-referenced maps included in the report.

Sample design – The 8 candidate outfall zones were surveyed completely, including overlap along transects. The design was comprehensive, extending lengthwise along the shore throughout the region of interest and offshore to depths of 30 m. The surveys were conducted during different seasons (fall and spring) in different years (1999 and 2001). Some text should be added explaining why surveys were undertaken during these periods and noting if the annual period for the greatest seasonal extent of submerged aquatic vegetation was captured by a fall and spring snapshot. Is coverage during summer greater? These questions could most likely be addressed by searching the literature for studies on the seasonal extent of submerged aquatic vegetation beds.

Sample analysis – Results are presented as a series of maps in the vicinity of each outfall zone displaying the submerged aquatic vegetation, cross-shelf corridors, potential outfall zones, candidate diffuser sites and depth contours. Some of the color patterns are difficult to distinguish (ex. dense eelgrass versus kelp and eelgrass) but the corridors for siting the outfall are clearly identified. A description of the findings for each area is described and a summary table is included.

<ins>Summary</ins>: The report is well written, the appropriate parameters were measured, the techniques used were state-of-the-art, the sample design was comprehensive and results were analyzed and presented in an easy to interpret fashion.

<ins>Specific Comments</ins> – A few typographic errors are noted below:

Page 4, paragraph 3, line 2 insert "to" in front of the word "distinguish"

Page 5, final paragraph, line 1 delete the word 'collected' when it appears a second time – changing the 1st sentence to: Because different teams collected sonar data in 1999…..

Page 6, paragraph 3, line 2 change ….area rather than at defined…to….area rather than a defined….(I think this sounds better but am not positive)

Page 6, final paragraph, line 2, change…affected on our ability… to….affected our ability…..

Page 18, Paragraph 1, line 5, change …. Multiple bands may to be present…. to….Multiple bands may be present….

END OF KELLER FULL TEXT REVIEW

Report Reviewed
Submerged Aquatic Vegetation Patterns in Candidate Outfall Zones

February 20, 2003

Douglas R. Levin, Ph.D.
Geologist for Marine Outfall Siting Study (MOSS) Peer Review
BrightWater Marine Outfall Siting Study

Summary

This evaluation is offered in the spirit in which it was assigned to the Puget Sound Marine Outfall – Formal Peer Review Panel. The comments are offered without the benefit of seeing the specifications requested of Parametrix prior to conducting the investigation for SAV Patterns in Candidate Outfall Zones. Due to the extremely poor quality of technical writing in this report, the scientific merit within is difficult to assess. Only the major problems are cited in this critique. The report is unfocused, poorly written, and uses terms incorrectly and inconsistently.

1. Were the studies designed appropriately, with sufficient data to satisfy the objective(s)?

There appears to be sufficient data to satisfy the objectives. The manner in which it is reported is deficient.

2. Is the science sufficient behind the conclusions in each report?

The science appears sufficient to answer the objectives posed by the DEQ's for eelgrass and kelp beds.

5. Was relevant data considered and used appropriately?

Relevant data was considered. If identifying corridors for crossing the SAV beds was the ultimate objective then the data is there. SAV maps were not created at the detail that Woodruff, et al. (2001), executed but appear to have the resolution required to make preliminary route selections.

6. Was something completely missed?

Review the following for additional and more detailed comments.

Brightwater Marine Outfall Conveyence System
Interim Conceptual Geotechnical Assessment
Parametrix, Inc.
September 2001

Report Comments:

1.0 Introduction

No comment

2.0 Field Methods

The readability of this report detracts from the scientific merit. For example, in the second sentence, p. 2, of this document ….”data were collected along multiple “track lines”….” The use of quotation marks around “track lines” is inappropriate. The term “track line” is a term commonly used in reference to the path taken by a boat to collect acoustic data. From The Chicago Manual of Style (1982): “Commonly known facts, available in numerous sources, should not be enclosed in quotation marks or given a source citation unless the wording is taken directly from another.”

Page 2: “Field methods for the 2001 survey were similar to those used in 1999”

--- Were they similar or were they identical? How were they different? No reference is cited here (assumed to be Woodruff, et al, 2001.

----It is unclear whether additional data was collected to supplement the SAV Pattern analysis.

Page 2: “Video data were used to ground truth sonar data, but other marine invertebrate and fish species have not been enumerated”.

---“Other marine invertebrate and fish species” suggests that some were enumerated. By definition “enumerate” means to itemize or spell out. The second part of this sentence does not follow the introductory part and is not necessary.

Page 2: “Spatial overlap of 1999 and 2001 data occurs between zones 6 and 7n (Figure 1)”.

----None of the figures (1, 7, or 8a) show where this overlap might have occurred.

3.0 Data Analysis Methods

Page 4 is wrought with technical writing problems and masks any scientific merit that might be brought to bear from the collected data.

Page 4: “…to convert track line data to image maps of the areas (mosaics).”

---- Track line data does not convert to mosaics. Track lines show the path that the survey vessel took to collect the data. The sonar imagery has navigation information imprinted in the data stream that allows a geo-referenced graphic image of the mapped area to be rendered.

---- There were ten cases within this page where quotations were used to offset a particular word or phrase. The syntax of the words within the text did not require quotations. e.g. “cover class”, “abundance”, (“morphometrics”), “covered”, “sampling unit”, “sample”, “presence”, “visually”, “within-patch”, “landscape attributes”.

Page 4: “Eelgrass polygons were created for several “cover classes”… The cover class segments, dense, moderate, sparse, and none to sparse were taken directly from Woodruff, et al, 2001 (p. 27) without citing it.

“The resolution at which cover classes were determined was not established *a priori*, but was determined during data analysis using best professional judgement (judgment is the correct spelling)”.

---- This sentence is awkward. Resolution has not been previously mentioned in the text to determine in what context it is being used. The term *a priori* translates loosely to “without prior knowledge”. Prior knowledge was furnished by Woodruff, et al in their 2001 field study. It is not acceptable to determine how to handle a data set after the data has been collected. Woodruff, et al (2001), had an extensive list of recommendations for conducting and improving upon their earlier program. It is unclear whether this study was used to further this program’s objective(s).

The seafloor mapping program was designed to identify the best corridor for the outfall. The decision should be based on a literature search and an interpretation of the data that was subsequently collected. Perhaps from that professional judgment can be used forthwith.

----In the third paragraph starting “Density and cover”… in this report we *would like distinguish…* this should read, “we would like to distinguish”…

----“density can be a good metric” …. metric refers to a measurement in the metric system, i.e. meters, kilometers, decimeters, etc. It is not a substitute for the word “measure”.

---- (“morphometrics”)…. This word is set off by quotations and parentheses.

Page 4: “Estimates of the mean and variance of density and cover are affected by the sizes, shapes, and arrangements of areas that are occupied by a species (patches) as well as the size and shape of the sampling unit used to measure abundance.”

----This sentence contains 42 words.
----This sentence is awkward and does not convey a clear or meaningful message.
----Mean and variance are statistical calculations they are not estimates.
---- In terms of technical writing, the word “patches” that is in parentheses should refer to the word that directly precedes it, which is “species”. It is assumed that it should have followed “areas” in this sentence.

---- There is no clear technical definition of the term “Patch”.

Page 4: “The sonar images were processed “visually.”

---- Sonar imagery may be processed using a variety of software and hardware features. It is analyzed visually.

Page 5: “SAV polygons classified as ‘dense’… whose longest side extends for at least thirty meters…”

---- Justify the use of 30m as a cutoff for dense.

Page 5: “SAV polygons classified as “moderate” describe patches of dense eelgrass where the patch…”

---- You can’t use the word “dense” to classify “moderate”. Dense has already been used in the first of the four classifications.

---- “None to sparse” is a conflicting partition. Woodruff, et al, 2001, uses “very sparse coverage for this classification.

Page 5: “SAV polygons were overlain on a map including 20 m bathymetry lines…”

---- Referring to the figures, this might mean the map contour interval was 20m.

Page 5: “Width measurements are likely accurate within 10 – 15 ft.

---- The previous figures in the report use the metric system. The mixing of SAE units and metric is not appropriate.

---- The use of the phraseology “likely accurate” does not convey any level of confidence. How was the accuracy confirmed?

Page 5: “In addition, for a portion…. overlain on the 2001 to further calibrate…”

---- “further calibration” suggests that some was done previously, please address this.
---- Did the different teams use the same equipment and frequencies?

4.0 Results

Page 6: The term “bands” is used for the first time in this report without a technical definition.

The two sentences that comprise the second paragraph on p.6 are disjointed. “Bands are distinguished by apparent differences in the distribution patterns….”

---- Apparent? or real differences?

Page 6, paragraph 3. "Because" should not start a paragraph or a sentence.

"Transitions between eelgrass meadows and other cover classes….."

---- Eelgrass meadows is not one of the four defined classifications, they are dense, moderate, sparse, and none to sparse.

Page 6, paragraph 4, "This is largely due to the fact that the longshore orientation of patches means that most transitions between patches tend to run longshore as opposed to cross shore".

---- The words longshore and patches are each used twice in the same sentence. "cross shore" is changed to "cross-shelf" in the subsequent sentence .

"In areas with multiple patches that lie cross-shelf to one another, transitions between patches run parallel to shore and do not appear as cross-shelf openings."

---- The terminology and structure used in statements like these are not informative.

Page 6, paragraph 6, "Any differences that may exist between the studies related to the classification of SAV abundance within polygons appear to be minor and, as with differences in polygon borders, do not affect the identification of cross-shelf pathways with "none to sparse" SAV greater than 25 ft in a longshore direction.

---- Technical writing should not have sentences longer than twenty-five words. This one has 49.

---- Tenses in the sentence changes from present to past and back to present.
---- A comma or other punctuation is necessary between polygons and appear.

"…. with "none to sparse" SAV greater than 25 ft in a longshore direction.

---- It is unclear where the 25 ft dimension is referring to.

Page 6, paragraph 6 "We feel very confident that none of the differences that would be expected to occur between surveys conducted at different times or by different teams affected on our ability to make decisions about the locations of cross-shelf pathways in SAV."

---- What differences would be expected?

4.1 Area-specific results

The most glaring change here is the change from using the metric system to feet.

Page 7, paragraph 6. "the entire nearshore area of candidate outfall zone 6 is covered by "sparse to none" SAV (Figure 7).

---- One sentence does not make a paragraph (seen at other points in this report).
---- “sparse to none” is not a classification “none to sparse” is.
---- The sentence is awkward. Using clothing as an analogy it would read: “The entire body was covered by little to no clothes”. Why not just say; “All of outfall zone 6 was classified as “none to sparse”.

Figures – General Comments

The shoreline is difficult to reference to the water.
The contours are not labeled and the minor contours difficult to see.
The shape of the moderate eelgrass is suspiciously geometric compared to the nearshore bed shapes.

References (for this document)

The Chicago Manual of Style, Thirteenth Edition, 1982, For Authors, Editors, and Copywriters, The University of Chicago Press, pp.738 (Prepared by the Editorial Staff of the University of Chicago Press, ISBN 0-226-10390-0

Woodruff, D.L., Farley, P.J., Borde, A.B., Southard, J.S., Thom, R.M., 2001, King County Nearshore Habitat Mapping Data Report: Picnic Point to Shilshole Marina, PNNL-13396; Battelle Marine Science Laboratory, Sequim, Washington, prepared for King County Department of Natural Resources, pp. 79 (plus figures).

END OF LEVIN FULL TEXT REVIEW

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

Respondent: Mike Burger, Parametrix

Aimee Keller

General question pertaining to sample design (surveying during different seasons and years):

1. Is coverage during summer greater?

> *RESPONSE: I would say that, in general, one could be pretty sure that coverage is greater in summer than winter but I would want to caveat that strongly and say that we do not have enough data to quantify the manner in which or the extent to which coverage changes between seasons. Summer coverage may be greater, but winter water clarity is greater and canopy kelps do not create as much shading. Greater water clarity allows more light to penetrate and colder temperatures slow plant metabolism so that sampling into the fall could potentially provide better images since there has been little change from summer eelgrass conditions and image quality is improved. Eelgrass does "die back" during the winter, but it does not always die back completely. It's density or condition may decrease within areas that it occupies and this may, in less densely covered areas, appear to reduce the area that is occupied (i.e., a sparse patch may "disappear" while a dense patch may just become less dense or shorter). I know of no data on the temporal variability in size, shape, or within patch density of individual eelgrass patches over seasons. The type and degree of change between seasons likely depends on both spatial and temporal factors such as exposure to wind and waves, substrate type, salinity, temperature, light (and shading from kelps), and even eelgrass density itself. When eelgrass density is at its maximum and minimum will also vary by year and, perhaps, even by location, so that the consequences of sampling at different times of year will vary by year and location. In general, it would be good to sample after the same number of degree days have passed in a year, but this is rarely feasible and sampling either takes place at the same time or opportunistically. We are currently doing a brief literature review of eelgrass patch dynamics to see what we can find out about this issue.*

Doug Levin

<u>From the full text review- referring to Section 2.0, Field Methods</u>:

Field methods for the 2001 survey were similar to those used in 1999.
1. Were they similar or were they identical? How were they different? No reference is cited here (assumed to be Woodruff, et al, 2001)?

> *RESPONSE: The citation of Woodruff et al. (2001) is in the first paragraph of that section. The main difference in methods was the actual hardware and software used and the fact that we collected video at the same time as the side scan data instead of*

collecting on different days. We did not read in USGS topo maps for our shoreline files but used shorelines provided to us by King County.

From the full text review- referring to Section 3.0 (page 5):

1. Did the different teams use the same equipment and frequencies?

	Parametrix	*Battelle*
Survey Speed	*3 Knots*	*3 Knots*
Sidescan Sonar Equipment	*Edge Tech DF1000 dual frequency sonar and Isis sonar acquisition system*	*GeoAcoustics LTD dual Frequency*
Frequency Used	*500 khz*	*??*
Firing Rate	*12 ping/s @ 50m range (1 pulse /0.15m) (2.5 samples / 6 cm perpendicular trackline)*	*200 ms (1 pulse /0.3m) (1 sample / 6 cm perpendicular trackline)*
Range	*50 m*	*60 m*
GPS	*Ashtech BR2G Differential GPS*	*Trimble GPS Pathfinder Pro XRS*
	12-Channel integrated GPS/beacon Satellite differential receiver	*12-Channel integrated GPS/beacon Satellite differential receiver*
GPS Accuracy	*0.5 m*	*0.5 m*
Mosaic Resolution	*0.1 m*	*?*
Trackline spacing.	*Since we were concerned with only two small specific areas, the surveys were conducted to provide 100% bottom coverage without regard to a defined trackline spacing. Realtime acquisition coverage maps were used in the field to verify coverage. Overlap >50% was achieved.*	*85 m (40% overlap)*

We did not have access to their raw data files, but the contrast in some of their .TIF files made it a little difficult to interpret images. This may have been due to the way their mosaics were created or data collection issues, but it is not possible to tell at this point with out the raw data.

From the full text review- referring to Section 3.0 (page 6):

Bands are distinguished by apparent differences in the distribution patterns

1. Apparent? or real differences?

RESPONSE: The intended meaning was that there were visually obvious (apparent) differences in the way eelgrass was distributed along the shoreline. In some areas the distribution had one pattern, in other areas a different pattern.

APPENDIX B-5

Core Subject Area →	**Chemistry**
MOSS Technical Documents Reviewed →	1. *Water Quality Status Reports for Marine Waters, 1999 and 2000.*
	2. *Water Quality Status Reports for Marine Waters, 2001.*
Peer Reviewers →	**Parker MacCready, Michael S. Connor, Aimee A. Keller, and Michael J. Mickelson,** Ph.D., Chemistry and Water Quality, Massachusetts Water Resources Authority
MOSS Technical Documents Reviewed →	3. *Geoduck Tissue Study, Brightwater Candidate Marine Outfall Zones, Sampling and Analysis Plan. April 2002*
	4. *Brightwater Marine Outfall: Geoduck Tissue Study Final Report. November 2002*
	5. *Existing Water Quality Conditions Study, Offshore Water Column and Intertidal Environments of the Central Puget Sound Basin, Sampling and Analysis Plan. June 2001*
Peer Reviewers →	**Michael J. Mickelson** and **Michael S. Connor**
MOSS Technical Documents Reviewed →	6. *Seasonal patterns and controlling factors of primary production in Puget Sound's Central Basin and Possession Sound Technical Memorandum. September 2001*
	7. *Seasonal patterns and controlling factors of primary production in Puget Sound's Central Basin and Possession Sound: assessing the role of nutrient limitation. November 2002*
Peer Reviewers →	**Michael J. Mickelson** and **Aimee A. Keller**
MOSS Technical Documents Reviewed →	8. *Brightwater Marine Outfall: Baseline Sediment Characterization Study – Sediment Chemistry and Benthic Infauna Final Report – November 2002.*
	9. *Baseline Sediment Characterization Study, Candidate Outfall Diffuser Sites, Sampling and Analysis Plan. September 2001*
Peer Reviewer →	**Michael S. Connor**

Documents 1 and 2: *Water Quality Status Reports for Marine Waters, 1999 and 2000, and 2001.*

Coordinator's Summary

The 1999-2000 and 2001 *Water Quality Status Report for Marine Waters* described ambient, point source, and MOSS water quality measurements. The reviewers were asked to comment specifically on the MOSS water quality monitoring portion of the documents. This partial review included, for both documents, sections 2.0, 2.2, 2.3, 2.7, 3.0, 3.2, and 4.0, as well as associated tables in Appendix A and Appendix F.

Examples of important shared findings by two or more of the reviewers: Monitoring goals should be re-evaluated and clarified, interpretation of the extensive data sets should be improved, documents should be better focused, and presentation, discussion and reporting of data should be revised.

Michael Connor: Ecology comments

The technical documents were reviewed separately and presented as two sets of comments. They are summarized independently below.

Summary for the *Water Quality Status Report for Marine Waters, 1999 and 2000*:

The reviewer acknowledged the ambient monitoring program as “among the most intensive programs in the country in terms of amounts and quality of data collected.” Nevertheless, the document could be improved in several ways.

The structure of the document and a “vague oceanographic discussion” hindered explanation of the water quality data. It was felt that a more effective method should include presenting information “in the context of a conceptual model of how the system works as gleaned from historic monitoring of the Sound.” Objectives of the MOSS portion of this study should be explicitly stated in the Executive Summary.

The reviewer expressed difficulty evaluating the adequacy of methods, analysis, and results through unclear Data Quality Objectives. Generally, detection limits and results appeared sufficient to comply with state standards, and “the data are consistent with analytical results in Massachusetts Bay and San Francisco Bay.” The detection limits for zinc are “somewhat higher” than the reviewer is accustomed to seeing, but “data for copper, nickel, and mercury appear to clearly meet risk assessment needs.” The sediment detection limits also are higher, and it was suggested “sediment cores may be a more appropriate way to evaluate outfall impacts than bottom grab samples.”

The water column data results could be presented more effectively. For example, temperature and salinity data should be discussed prior to bacteria data, the “CTD monthly color graphs” were more useful than depth charts, and percent saturation data should be available to allow interpretation of oxygen data. Nutrient relationships (i.e., ammonia, nitrate, silica) were discussed, but these data “[were] not presented graphically in a way that makes any particular point.” Also, “depth-integrated chlorophyll might be more useful than showing that chlorophyll is not found in deep water.”

Further, plotting on a map the average concentrations of water column metals could be useful in discerning any distribution patterns. Similarly, “the tracer data would be more useful if the average amounts of coprostanol and caffeine in effluent were presented.” Benthic community results were not “effectively explain[ed],” and it was not clear “if the authors believe[d] the differences [were] statistically significant or whether any trends exist.” More importantly, the experimental design may not allow "one to reach the conclusion that these outfall sites [were] different from normal background areas."

Finally, the reviewer suggested combining beach and water column data, as well as merging the shellfish tissue bacteria section with the water column bacteria section. It would be important to explain the "difference in methodologies between shellfish and water and why they may not correlate."

Recommendations: 1) List the general water quality parameters (GWQP); 2) specify clearly the Data Quality Objectives; 3) silver could be an option "for tracing wastewater fate and transport" and should be explored; 4) water column data results would be better realized if wet and dry conditions were separated and point/non-point sources noted; and 5) data presentation and discussion should be "extensively revised."

Summary for the *Water Quality Status Report for Marine Waters, 2001*:

In addition to the summary notes above, the reviewer provided comments specific to the 2001 document:

Multi-year comparisons were few in number, "yet these multi-year trends are what give the report its context to the outside reader." In general, "impacts from existing discharges" were not effectively evaluated, preventing the outside reader from "determin[ing] the extent of the problem, whether it is getting worse, and the likely causes."

The salinity and density section should be re-evaluated in terms of content and utility. Graphical illustrations of DO at offshore stations and "ammonia concentrations at beach stations" would be more meaningful and accessible if presented differently. Further, "the chlorophyll section would benefit from an analysis of limiting factors" and should be illustrated in some way. Also, because of the way data were presented, it was difficult "to estimate where sediment concentrations [were] elevated compared to background."

Recommendations: 1) Where relevant, incorporate applicable data collected by other agencies; 2) consider a "partnership between King County and University of Washington's Sea Grant program to sponsor some small grants to develop some insightful data reporting techniques;" and 3) consider "re-designing the monitoring program based on the extensive experience of the existing monitoring program and changing public perspectives."

Aimee Keller: Biology comments

The technical documents were reviewed separately and presented as two sets of comments. They are summarized independently below.

Summary for the *Water Quality Status Report for Marine Waters, 1999 and 2000*:

In general, the parameters measured "form a solid water quality program" and should provide sufficient data for use in the siting process. Though not a standard parameter, monitoring of biological samples such as phytoplankton, zooplankton, and primary productivity would "help address the question of impacts to the system as a result of the outfall." For example, "given the unknown but presumed anthropogenic cause for the increase in harmful algal blooms in coastal waters, measurement of phytoplankton composition and abundance would enhance the program and address long term effects."

Productivity measurements undertaken as part of this program but reported elsewhere should be referenced in this document. As indicated in the kick-off meeting, the measurement of "estrogenic effects" is important, and if considered, "some mention of this possibility should be incorporated in the water quality report."

The measurement methods were "approved and acceptable" for water quality analyses, but references for cited methods were not listed. Specific reference to "whole water samples being taken for chlorophyll *a*" was not noted, and GWQP's were not listed. The reviewer suggested underwater light meters would produce "more precise estimates of light attenuation."

Underwater profile data should include additional depths "in the upper portion of the water column…to improve the ability to fit the equation [light attenuation coefficients based on the exponential model for decay of light with depth]." Light intensity values "beyond the detection limit of the equipment being used" should not appear in tables. Lastly, the report failed to reveal the "historical extent of the light component" in the existing water quality database, limiting the reviewer's ability to "judge whether there is a significant loss of information if a switch is made from collecting light extinction using the secchi disk to a light meter."

The rationale behind the sample design for the water quality portion of the MOSS was not explained, nor was an explanation provided "for the change in number of stations and station locations between the two years." The reviewer stated that the sampling program must be predicated on "solid statistical design and be presented in terms of potential outfall sites and effects." Separating the MOSS portion from the "routine [water quality] monitoring program" and reporting in a separate document should be considered. Lastly, the design was adequate to "answer questions about the impact of the new outfall on water quality but the presentation needs work."

"Data analysis in general [was] descriptive and lack[ed] synthesis, particularly in reference to siting a new sewage outfall." Since "an enormous amount of data was collected," the results must be synthesized and "related to potential outfall sites to be useful to decision makers." These analyses are essential if the data are to be determined "sufficient to answer the siting criteria questions." The document as a whole should be better focused.

The "overall importance of stratification to the siting procedure" should be highlighted. In addition, "long-term trends" in water quality data should be explored "and the results discussed in relation to an additional wastewater treatment facility being built." Statistical analyses "should be undertaken for all measured parameters." Finally, the reviewer suggested adding a "bulleted summary" to each report section highlighting spatial and temporal change for parameters, "present and past results" helpful in siting an outfall, and statistical analyses of existing data to identify significant differences, trends, or natural variability.

The reviewer mentioned that although eutrophication is "not a current problem in the main basin, … adding additional human derived nutrients to fuel further phytoplankton growth on top of naturally low oxygen concentrations could rapidly produce deleterious effects."

Recommendations: 1) Use a light meter for sampling transparency; eliminate the secchi disk; 2) add a section outlining "the goals of the water quality monitoring … in terms of siting a new outfall and how those goals were addressed by the chosen sampling design;" 3) separate the MOSS program from the other monitoring programs, "cross-referencing the stations in common to both programs;" 4) percent saturation should be discussed in the DO section and "concentrations of DO in bottom water should be graphed;" 5) "the discussion on enterococcus bacteria would benefit from a seasonal plot or a plot of abundance versus rainfall to demonstrate the lack of correlation between the two measurements;" 6) "show seasonal cycles for surface and bottom nutrient concentrations rather than profiles;" and 7) modify Figure 3-20 by "plotting surface and bottom concentrations of NO3 + NO2 over the seasonal cycle."

Summary for the *Water Quality Status Report for Marine Waters, 2001*:

In addition to the summary notes above, the reviewer provided comments specific to the 2001 document:

A discrepancy was noted between data reported in several of the tables and data listed in the Appendices (e.g., number of measurements for each station over time). The reviewer did not compare all entries, but mentioned that the "tables should reflect the actual measurements made not those which were planned."

Exceedingly low concentrations of dissolved oxygen were observed at several beach stations during one summer month. The reviewer stressed the importance of this finding "given the importance of nearshore environments to listed species," and suggested careful examination. In addition, further study may be needed if there exists a "relationship between algal growth and decay fueled by added nutrients in wastewater."

Additional graphs should be generated to provide information to managers regarding "variation among stations …and relationships among measurements." The reviewer provided two graphical examples: "seasonal changes in chlorophyll concentration at a MOSS station…versus an ambient station," and the "inverse relationship" between chlorophyll *a* and dissolved inorganic nitrogen. A third graphical example displayed differences in surface and bottom water concentrations that "would help define the periods when stratification is important and nutrient limitation may be occurring."

Recommendations: 1) For regulatory standards in Section 2.7, "include a section and table for DO… and a table showing EPA's heavy metal tissue-residue standards;" 2) "plot nutrient concentrations on a seasonal basis, variations among stations and differences between surface and bottom concentrations rather than representative profiles for 6 stations;" 3) track a few variables long-term to "appear as graphs to illustrate changes in water quality in the Sound over time;" and 4) "the transect data and the water column monitoring data should be cross-referenced."

Parker MacCready: Oceanography comments

The technical documents were reviewed together and presented as one set of comments. They are summarized together below.

The reviewer commented primarily on the data presentation of physical properties (i.e., CTD data). Both reports would have benefited from "data plotted in an along-channel format, instead of just separate cross-channel sections." A "graphical sense" of the "along-channel density structure … between Pt. Wells and Possession Sound" could help to explain flow paths entering Possession Sound (e.g., mid-depth water or other depths in the water column). An additional CTD section in northern Possession Sound would be helpful.

Suggestions for improving the data presentation included additional contour lines to help discern deep-water properties. For example, "a common technique used in the blue-water oceanographic literature is to split a section into two panels, one of which covers just the top, highly stratified, layer."

Michael Mickelson: Chemistry comments

The technical documents were reviewed together and presented as one set of comments. They are summarized together below.

The baseline water quality data was "solid," and several locations would be suitable for an outfall, especially Point Wells. The monitoring programs detected few if any signals from existing outfalls, "whether in nutrients, toxics, or pathogen indicators; the effluent load is tiny compared to natural loads." The reviewer commented on the weak stratification for much of the year and wondered if a plume would tend to surface.

Graphical illustrations were produced by the reviewer and can be found in the full text review. Both illustrations used data from the 1999-2000 *Water Quality Status Report.* First, nitrogen versus phosphorous limitation at an existing outfall monitoring site was plotted. The reviewer was "impressed" at the elevated nitrate concentrations and commented on the "clear relation between chlorophyll and the deficit in nitrate compared to winter values, except [for summer imbalances where] either particulate nutrients are sinking and being stored in sediments…or the offshore nitrogen has that same seasonal pattern."

The second graph illustrated a "crude nutrient balance" with nitrate, chlorophyll, ammonium, and total phosphorous levels occurring at one existing outfall monitoring site. Much nitrate was present during the year, but was "reduced in surface waters in summer [with] the deficit show[ing] up as chlorophyll."

Offshore loads of nitrogen are greater than effluent loads of nitrogen. A crude calculation revealed “200 outfalls would just match the [nitrogen] load from offshore,” based on concentrations and flows so the “load from Brightwater would be 0.5% of the offshore load.”

The reviewer felt the resulting potential “0.5% increase in chlorophyll” could not be detected “baywide.” Finally, the strongest outfall signal (ammonium) at an existing monitoring site corresponded to a 50:1 dilution.

Recommendations: 1) For changes in chlorophyll, “include satellite imagery in the reports to show the extent of blooms;” 2) specify percent saturation “when discussing low DO concentrations;” 3) “use a log color scale for PAR irradiance” (Figure 4-1 for each report); 4) “the goals of the monitoring should be reviewed and stated as clearly as possible to balance effort to detect the outfall signal versus effort to chronicle natural variability;” 5) clarify monitoring goals “to balance a restricted focus on testing for evidence of exceedance of criteria versus evaluation of patterns and processes;” and 6) “recommendation of information gaps such as how local change in nutrients is related to offshore waters versus seasonal sinking to sediments.”

Documents 1 and 2: *Water Quality Status Reports for Marine Waters, 1999 and 2000, and 2001*.

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Puget Sound Peer Review

Reviewer: Michael Connor

Document **Water Quality Status Report for Marine Waters 1999-2000.**

General Comments

This section establishes baseline water quality prior to the outfall. Stations captured inputs, historic outfall sites, and conditions near the new outfall. It builds on the ongoing monitoring program in Puget Sound. The ambient monitoring program ranks among the most intensive programs in the country in terms of amounts and quality of data collected.

However, this report suffers because of its vague oceanographic discussion. It would be much more effective if it were presented in the context of a conceptual model of how the system works as gleaned from historic monitoring of the Sound. In some ways, this integration is hampered by the structure of the report itself. For instance, by reporting the Physical Oceanography information elsewhere, explanation of the water quality information is hampered.

Specific Comments

Exec Summ, p. v

The opening paragraph would benefit from an explicit statement of the objectives of this special study—e.g. “our goal was to have sufficient stations to characterize sediment and water quality in the…”

Exec Summ p. vii

The phytoplankton bloom observations are left without context. Can the timing of the bloom this year be explained by light, nutrients, or timing of stratification?

The organics data also lack context. If there are no standards and no comparisons to other areas or other standards, why bother collecting this information?

Exec Summ p ix

The CTD discussion is symptomatic of the general issues within the Executive Summary. The discussion—“transect data indicated patterns consistent with observed and suspected circulation patterns of the Central Basin and Possession Sound"—does not provide much useful information to the reader.

Sec 2 Tab 2-1 Define GWQP to say what it includes. A later table does this well.

Sec 2.3 p.2-14 It is hard to comment on methods without explicitly knowing the Data Quality Objectives. If it is important to characterize when and where nutrients are limiting then it would be important to determine when nitrogen and silica are at 0.5 micromolar and phosphorus at approximately 0.05 micromoles.

Sec 2.3.8 p.2-18 Again, absent clear Data Quality Objectives, it is hard to evaluate the sufficiency of methods and analysis. In general, detection limits and results seem to be sufficient to demonstrate compliance with state standards. The data are consistent with analytical results in Massachusetts Bay and San Francisco Bay. The detection limits are somewhat higher than what I am used to—in particular for zinc which is a common wastewater constituent—however, the methods may be sufficient for your data quality objectives. Data for copper, nickel, and mercury appear to clearly meet risk assessment needs.

Sec 2.4.6 p.2-21 Data Quality Objectives need to be clearly stated. Sediment cores may be a more appropriate way to evaluate outfall impacts than bottom grab samples (see http://geology.wr.usgs.gov/wgmt/bostonharbor/boston5.html or http://marine.usgs.gov/fact-sheets/fs 150-97.) The sediment detection limits are higher than what I am used to in Mass Bay and San Francisco Bay, but are sufficient to compare to Washington management standards. You may be losing an opportunity for tracing wastewater fate and transport using silver, quite successfully used to tract wastewater inputs 50 miles away (see http://geology.wr.usgs.gov/wgmt/bostonharbor/boston6.html)

Sec 2.5 p.2-23 The use of outside taxonomists for QA is good. It would be helpful to note where reference collections are stored.

Sec 3.2.1p.3-3 This section has the challenge of presenting lots of data that are mostly negative. Table 3-1 and 3-2 and Figure 3-4 are helpful ways of presenting the information. The information could be better understood by delineating between wet and dry weather conditions and noting the presence or absence of known sources—stormwater pipes, agricultural fields, etc. Figures 3-3 and 3-6 are not very helpful in presenting information. Mostly, a reader would want to understand what caused the measurable values.

Sec 3.2.2 p.3-11 It seems odd to discuss temperature and salinity after bacteria data. I would combine this section with the latter CTD section and put it first. I don't find the depth charts very easy to read nor helpful. The CTD monthly color graphs are much more accessible.

Sec 3.2.4 p.3-16 The oxygen data would be easier to interpret if the percentage saturation data were calculated and presented. I'm not sure the benefit of Fig 3-15. I don't know how to interpret the higher readings without knowing the percentage saturation.

Sec 3.2.5 p.3-20 The basic question here is to determine where the mixed layer depth is compared to the level of light penetration. In addition, we want to know how much light absorbance is due to phytoplankton vs. turbidity. Using the Secchi depth and the light data, it should be easy to calculate the extinction coefficient and the depth of the 0.5 or 1% light level. There are also easy ways to calculate light absorbance by phytoplankton and particles. The Van Voorhis and Newton paper provides a great template for presenting these data.

Sec 3.2.6 p.3-21 The conceptual model I start with is that ammonia is the first nutrient to disappear in the summer because of phytoplankton uptake or nitrification. We might expect to see ammonia released from the sediments. Nitrate could be limiting in the summer with sufficient surface water stratification. Finally, silica could be secondarily limiting in the summer, which may be important for the potential for harmful algal blooms. The data seem to document these ideas, but are not presented graphically in a way that makes any particular point.

Sec 3.2.7 p.3-27 Depth-integrated chlorophyll might be more useful than showing that chlorophyll is not found in deep water.

Sec 3.2.8 p.p3-33 There seem to be two relevant questions: do metals exceed standards and is there any pattern to their distribution? The first question is adequately addressed. The second question is not effectively addressed. Plotting average concentrations on a map might be a helpful way to evaluate this second question. Beach and water column data should be combined. The relevant criterion is not human health.

Sec 3.2.10 p3-44 The tracer data would be more useful if the average amounts of coprostanol and caffeine in effluent were presented.

Sec 3.3.4 p. 3-58 This section presents a number of indices that are standardly used. It does not effectively explain or indicate any spatial patterns or trends. I can't tell if the authors believe the differences are statistically significant or whether any trends exist. It's not clear that the experimental design allows one to reach the conclusion that these outfall sites are not different from normal background areas.

Sec 3.4.4 p.3-67

I would put this section together with the water column bacteria, explaining the difference in methodologies between shellfish and water and why they may not correlate. Presumably shellfish integrate over a two or three-week timeframe as compared to the surface water measurements.

Sec 4 p. 4-1

I would insert this section describing where the water goes in Section 3 before the Biology.section. This information could be useful in explaining the water quality data. I found the discussions of the impacts of weather patterns on page 4-10 to be helpful in explaining the water quality data. A popular template for water quality data can be found at http://sfbay.wr.usgs.gov/access/wqdata/overview.

Summary

This report suffers from the issue of simultaneously discussing compliance with standards with providing enough information about oceanography to explain the causes of non-compliance. This is a difficult challenge—Massachusetts Water Resources Authority, San Francisco Estuary Institute, New York City, and Southern California Coastal Water Resources Program take slightly different approaches. The audience for this report seems to be the moderately interested member of the public. If the report is to have credibility within the marine science community, the way that data are presented and discussed needs to be extensively revised.

References

Some relevant websites are cited above. The US Geological Survey makes strong use of fact sheets.

END OF FULL TEXT REVIEW

Puget Sound Peer Review

Reviewer: Michael Connor

Document	**Water Quality Status Report for Marine Waters 2001.**
General Comments	My comments on the structure of this report mirror my comments on the previous year's report. In addition, I was struck in this year's report about how few multi-year comparisons are made; yet, these multi-year trends are what give the report its context to the outside reader. The report also doesn't effectively evaluate the impacts from the existing discharges in an explicit way that the reader can follow. There is some evidence of extensive nutrient regeneration near the West Point outfall, regional indications that beaches are suffering significant eutrophication problems, and rainfall-associated bacterial violations. In all these cases, the issues are not explored in much depth that would allow the reader to determine the extent of the problem, whether it is getting worse, and the likely causes.
Specific Comments	
Sec. 1.1, p. 1-1	Many agencies are collecting relevant data in the Sound. It would be nice to see the report incorporate this other information where relevant.
Sec. 2.4.6, p. 2-19	The top 2 cm are used for analysis here compared to the top 10 cm in the baseline sediment characterization study. The HYPACK positioning system is a nice improvement. At some point, it would be worth evaluating the cost effectiveness of collecting some sediment cores to determine if nearfield stations are being impacted.
Tab 3-3, p. 3-7	It would be useful to have a more explicit comparison of bacterial numbers as a function of antecedent rainfall.
Fig 3-4/5, p. 3-8	Wouldn't this graph be more relevant as a frequency histogram on the y-axis? The x-axis has an odd mixture of bins for the scale. It might make more sense to do a log-transform.
Fig 3-9, p. 3-11	Why not present this as a regression?
Fig 3-10/11, p. 3-12	Same comments as above.
Sec. 3.2.3, p. 3-13	This section needs re-thinking about what's being presented and how to use it. Salinity would help explain the freshwater loads of bacteria. Density would help explain blooms.

Fig 3-16, p. 3-19	Lumping all depths and seasons together obfuscates much of the insight into what's happening. One graph of bottom water oxygen or percentage saturation would be more meaningful than this graph.
Sec. 3.2.5, p. 3-19	This discussion doesn't provide much useful information. I'd like to know things like whether the mixed layer is light-limited.
Sec. 3.2.6, p. 3-22	Overall mean ammonia concentration is an odd statistic—somewhat equivalent to overall average dissolved oxygen concentration.
Fig 3-20, p. 3-24	All these beach data summaries would be more accessible plotted on a map.
Fig 3-25, p. 3-30	Any correlation between pH and chlorophyll?
Sec. 3.2.8, p. 3-31	The chlorophyll section would benefit from an analysis of limiting factors. It appears that nitrogen, silica, and light can all be limiting. These situations can be simply calculated and displayed.
Tab 3-8, p. 3-36	The seasonal data seem to suggest that phytoplankton production is impacting dissolved metal concentrations.
Sec. 3.2.10, p. 3-41	The presence of caffeine provides a nice way to estimate the amount of dilution the waste is receiving. This calculation would be an interesting graphic.
Sec. 3.3 p. 3-41	While the goal is stated as trying to evaluate the effect of point sources, the data are not presented in any way that allows the reader to make that assessment. Even with the methodology problems, it should be possible to estimate where sediment concentrations are elevated compared to background.
Tab 3-17, p. 3-51	Isn't the TOC and %OC the same number? Why show the conversion?
Sec. 3.4.1 p. 3-54	Why graph percentage lipids? Isn't it just natural variability?
Sec. 3.4.2 p. 3-55	A comparison to the previous years' data would be helpful.
Sec. 3.4.3 p. 3-55	Benzoic acid also showed up in the baseline sediment study. Could there be a lab contamination issue?
Sec. 3.4.4 p. 3-58	I found the discussion puzzling. Why not present a regression plot?
Sec. 3.5, p. 3-59	There was some suggestion of trends. The reader would like the report to answer the questions: are the point-source station elevated? Are the point source stations all equivalent? Are the

reference stations truly unimpacted? Do the areas with high metals correspond to the local loadings? Do the algae levels correspond with the water column measurements?

Summary

As an outsider, I am struck by how extensive the data sets are. They include a large amount of spatial and temporal data that appear to be of quite high quality. In reviewing national coastal monitoring programs, the National Research Council observed that generally not enough money is spent in interpreting and thinking about the data collected compared to the money spent on data collection and laboratory analysis. The extent to which this closer look would be valuable depends on whether the data are simply to check for compliance with water quality standards or can be used to understand the rigor of the standards, potential interactive effects, etc. It might be worth a partnership between King County and University of Washington's Sea
Grant program to sponsor some small grants to develop some more insightful data reporting techniques.

It would also be worth thinking about re-designing the monitoring program based on the extensive experience of the existing monitoring program and changing public perspectives. It's a healthy exercise and can also be used to garner re-invigorated public support.

END OF CONNOR FULL TEXT REVIEW

Review Date: February 4, 2003
Reviewer Name: **Aimee A. Keller**
Technical Document being reviewed: **Water Quality Status Report for Marine Waters, 1999 and 2000**

General Comments:
The document describes the ambient and point source water quality measurements made over a two-year period (1999 –2000) as part of King County's marine monitoring program. Included in the document are results for additional monitoring undertaken as part of the siting procedure for a new marine outfall. I completed a partial review of the document focused primarily on introductory comments, water column monitoring for the Marine Outfall Siting Study (MOSS), CTD transects and selected data appendices. My general comments are subdivided into four categories: variables measured, measurement methods, sample design, and data analysis.

Variables measured: King County regularly monitors a standard set of water quality parameters used as indicators of environmental change in coastal waters. These variables include: physical measurements (temperature, salinity, density), light intensity (PAR), secchi transparency, nutrient concentrations (NH_4, NO_2 + NO_3, total P, SiO_4), turbidity, total suspended solids (TSS), fecal coliform bacteria, chlorophyll *a*, phaeophytin, and dissolved oxygen. Additional parameters were added to the routine sampling program for the MOSS project including organics (polynuclear aromatic hydrocarbons, pesticides, polychlorinated biphenyls, and chlorinated herbicides) and total and dissolved metals. The routine and added parameters measured form a solid water quality program and should adequately provide information of use in the siting procedure. Notably absent from the measurements however, are biological samples for phytoplankton, zooplankton and primary productivity. As part of the siting procedure for the marine outfall, productivity measurements were undertaken and are described in separate documents. Reference to these measurements should be made in the water quality report. Monitoring the phytoplankton and zooplankton communities would help address the question of impacts to the system as a result of the outfall. Given the unknown but presumed anthropogenic cause for the increase in harmful algal blooms in coastal waters, measurement of phytoplankton composition and abundance would enhance the program and address long term effects. Although not standard water quality parameters, these variables are frequently included in water quality programs addressing impacts to systems as a result of wastewater treatment.

At our initial meeting in January, we also discussed the importance of measuring estrogenic effects as part of the siting procedure. The water quality team responded that they were aware of the need for such measurements and were conducting preliminary studies to determine if such measurements should be included in the routine monitoring. Some mention of this possibility should be incorporated in the water quality report.

In general, the parameters being monitored for the MOSS program provide a strong database for use in the siting process. The addition of phytoplankton and zooplankton to the monitoring program, while desirable, is not essential to address water quality concerns arising from a new sewage outfall in Puget Sound.

Measurement methods –Table 2-6 lists the methods used for the various analyses; the table should include references for cited methods, presumable APHA (1992) and EPA (1995). The methods cited are the scientifically accepted and approved methods for water quality analyses. No mention is made in the text of whole water samples being taken for chlorophyll *a*, although samples were taken for nutrients, TSS, bacteria and organics. Presumably the CTD profiler measured in vivo fluorescence, which was calibrated to chlorophyll *a*, using the water sample collected in the Niskin bottles. This should be noted in the report.

It seems redundant to measure both secchi disk transparency and light intensity as part of the same program. The secchi disk is used to estimate the clarity of the water. However, as noted within the document, the procedure is somewhat subjective. The individuals taking the measurements, as well as wind and wave conditions can introduce variability. More precise estimates of light attenuation may be made with underwater light meters. To compare underwater light availability, light attenuation coefficients (k, m^{-1}) are typically calculated based on the exponential model for decay of light with depth (using profile data). The depth of the photic zone (Z_p, 1% PAR, m) is readily obtained in a similar fashion. The underwater profile data are already being collected, although additional depths in the upper portion of the water column should be included to improve the ability to fit the equation. The disadvantage of switching to the extinction coefficient, as the sole measure of transparency would be the inability to compare current and future data with historical data collected prior to the use of the underwater light profiler. No mention is made within the report of the historical extent of the light component of the water quality database, so I am not able to judge whether this is a significant loss. For continued sampling of transparency for the MOSS component of the water quality monitoring I would recommend using the light meter and eliminate the use of a secchi disk.

Sample design – No explanation is given for the rationale behind the sample design for the water quality component of the MOSS program, in terms of station location, number of stations, depths sampled, sampling periodicity, transects versus discrete stations, beach versus water column stations etc. No explanation is given for the change in number of stations and station location between the two years. A section needs to be added stating what the goals of the water quality monitoring are in terms of siting a new outfall and how those goals were addressed by the chosen sampling design. The sample program needs to be based on a solid statistical design and be presented in terms of potential outfall sites and effects. This would most easily be accomplished by separating the MOSS water quality program from the routine monitoring program and presenting it as a separate document, cross-referencing the stations in common to both programs. Alternatively, section 2.2 could be expanded and the explanation for the chosen sample design added. An explanation was given for including transect data - to acquire information for developing a model. I believe the design is sufficient to answer questions about the impact of the new outfall on water quality but the presentation needs work.
Data analysis – Data analysis in general is descriptive and lacks synthesis, particularly in reference to siting a new sewage outfall. Again part of the problem may be inclusion of the results from the siting study within a general report on the water quality of Puget Sound. Does the water quality study provide information of use in siting the outfall? Are any sites better then other sites based on the results observed? Even as a general document describing the water quality in the main basin of Puget Sound, the document needs focus. Is water quality really so high that eutrophication within the basin in non-existent? In many cases the answer to this

question appears to be yes – but this needs to be clearly supported. However, attention should also be focused on problem periods (i.e. periods of intense water column stratification coupled with high phytoplankton biomass) and/or sites with potentially existing water quality problems (i.e. Elliott Bay and Possession Sound). The overall importance of stratification to the siting procedure needs to be emphasized.

I also did not find a comparison of the current study with past surveys except in very general terms. Have any of the MOSS sites been previously sampled? Has water quality in general in the Sound changed in recent years? With a database containing 20 years of data, the potential for seeing significant long-term trends should be explored and the results discussed in relation to an additional wastewater treatment facility being built.

One suggestion would be to add a bulleted summary at the end of each section emphasizing: a) how a specific parameter has changed over time; b) how the parameter varies spatially; and c) how the present and past results are useful in siting the outfall. Also some statistical analysis of the existing data should be included: a) are there significant differences among stations or groups of stations; b) has the parameter shown any trend over time; c) are the trends related to wastewater treatment or an expression of natural variability? A statistical analysis of the trace metal data is described as forthcoming, similar analyses should be undertaken for all measured parameters. An enormous amount of data was collected, however the results need to be synthesized and related to potential outfall sites to be useful to decision makers. Without these analyses it is difficult to determine that the data are sufficient to answer the siting criteria questions.

Additionally, the relationship between water quality response variables (ex. chl, DO) and living resources (ex. fish, eelgrass, geoduck) needs to be explored at some point in the text.

Summary: Sufficient water quality data have been collected to address questions about where an outfall should be cited to minimize impacts. Methods are approved and acceptable. Report needs to address relationships between results and siting procedure, preferably using statistics. The relationships may change depending on the parameter being examined.

Specific Comments:

Executive summary – page vi, line 1 *E. coli* is mentioned for the 1st time and should be called *Escherichia coli*, this does not happen until section 2.3 page 2-15.
Figure 1-1 – The text (section 1.3) refers to specific locations in figure 1-1 but these locations (i.e. Tramp Harbor, Normandy Park, Richmond Beach etc.) are not shown in the figure. They should be added.

Table 2-1. Footnote 2 defines GWQP as general water quality parameters but does not list them (physical prop., DO, chl, Bacteria, nutrients) – add the list.

Section 2.2.1 – No mention is made of sampling frequency – this would be a good place to state that samples were collected monthly.

Nutrient abundance should be nutrient concentration (pg 2-8)

Add rationale for sample design to this section

Page 2-12 state the actual figure number from section 4 which shows the transect locations

Section 2.2.2 change ‘Seven stations are new, and have never been sampled previously’ (redundant) to- ‘Seven stations are new, while three ….. are also monitored as part of the marine ambient monitoring program’ …

Section 2.3.1 at the end of 1st paragraph, change ‘… and are easier and safer to test in the laboratory’ to ‘their presence is easier and safer to detect than disease causing bacteria’.

Page 2-15, 1st paragraph – The presence of viruses and toxic dinoflagellates are mentioned as not being detectable by the fecal coliform method and reference is made to separate collection of these data as a necessity – I could not find any additional reference to whether these variables are ever measured.

Section 2.3.3 Define hypoxic as a specific concentration of DO. Relate known low DO concentration to known effects.

Section 2.3.5 diatoms are phytoplankton and should not be separated out as done in line 5.

Section 2.3.6 Seasonally low oxygen concentrations can be found at depth throughout Puget Sound. Productivity related oxygen deficits are maximized during late summer. Adding additional human derived nutrients to fuel further phytoplankton growth on top of naturally low oxygen concentrations could rapidly produce deleterious effects. Although eutrophication is not a current problem in the main basin of Puget Sound the potential for problems should be recognized because of the small margin of error existing due to naturally occurring low DO levels.

Section 2.3.7 Throughout the text phaeophytin is spelled as “pheophytin” however in data appendices it is spelled as “phaeophytin”. I have always used phaeophytin but believe either spelling is accepted???? But consistency is important.
Section 2.3.8 No mention is made of collecting chl samples from the Niskin bottles but this must be done to calibrate the in vivo fluorescence measurements.

Subsection Laboratory Methods – pg 2-19. A reference is cited as (APHA 1995). The reference is listed as 1992 in the literature cited section.

Section 2.7 Regulatory standards – include a section and table for DO. Include a table showing EPAs heavy metal tissue-residue standards – referred to in section 2.7.4

Section 3.2.1 add reference to Table 2.10 at end of sentence 3 ….standards (Table 2-10).

Subsection Beaches – Label the beach stations in Figure 3-4 so that a reader can identify where they are located.

The discussion on enterococcus bacteria would benefit from a seasonal plot or a plot of abundance versus rainfall to demonstrate the lack of correlation between the two measurements. Results should be summarized by station in a table showing mean, max, min, std, se or similar statistics, similar to the tables in the trace metals section. Logarithmic plots are often used for presenting bacteria counts.

Section 3.2.2 This section states that Figure 3-11 shows the seasonal pattern for all beach stations – figure 3-11 is not a seasonal plot.

Section 3.2.3 Salinity is usually carried to a single decimal place.

Section 3.2.4 Final line on pg 3-16 ‘show’ should be ‘shown’. Concentrations of DO in bottom water should be graphed – perhaps as an added variable in figure 3-15. Some discussion of percent saturation should be included in the DO section.

Section 3.2.5 The units for PAR are usually written as $\mu mol/m^2/s$ or $\mu mol\ m^{-2}\ s^{-1}$; Calculate the depth of the 1% light level since this depth is considered the depth of the photic zone rather than assuming ‘that most photosynthesis occurs between the surface and 25 m’.

Section 3.2.6 The final line on page 3-21 is incomplete.

Why was a standard temperature of 15°C, salinity of 30 ppt and pH of 8.0 used to calculate the ammonia criteria rather than the actual temperature, salinity and pH at the times and locations where samples were collected?

Show seasonal cycles for surface and bottom nutrient concentrations rather than profiles, they provide greater information for the changes occurring over time. Or alternatively show contour plots over the seasonal cycle.

Figure 3-20 could be modified to provide more information by plotting surface and bottom concentration of $NO_3 + NO_2$ (+standard errors, by station) over the seasonal cycle. The nutrient section should compare results from the most recent surveys to past surveys to establish changes over time.

Section 3.2.7 Seasonal plots of surface, bottom or depth averaged chl should be shown

Section 3.2.8 through Section 4 were more informative and did a better job of summarizing data but also need to be tied to the potential outfall sites.

Appendix A-1 Light intensity decreases with depth exponentially. If values remain the same as depth increases then the values are beyond the detection limit of the equipment being used and should not be shown in the tables. This happens repeatedly and in other appendices as well

Appendix F-2 – why is no bottom depth shown for the Lake WA Ship Canal?

END OF FULL TEXT REVIEW

Review Date: February 19, 2003
Reviewer Name: **Aimee A. Keller**
Technical Document being reviewed: **Water Quality Status Report for Marine Waters, 2001**

General Comments:
The document describes the ambient and point source water quality measurements made during 2001 as part of King County's marine monitoring program. Included in the document are results for additional monitoring undertaken as part of the siting procedure for a new marine outfall. I completed a partial review of the document focused primarily on introductory comments, water column monitoring for the Marine Outfall Siting Study (MOSS), CTD transects and selected data appendices. My general comments are subdivided into four categories: variables measured, measurement methods, sample design, and data analysis. Since the format for the 2001 water quality report closely follows the report for 1999-2000, my general comments remain somewhat the same.

Variables measured: King County regularly monitors a standard set of water quality parameters used as indicators of environmental change in coastal waters. These variables include: physical measurements (temperature, salinity, density), light intensity (PAR), secchi transparency, nutrient concentrations (NH_4, NO_2 + NO_3, total P, SiO_4), turbidity, total suspended solids (TSS), fecal coliform bacteria, chlorophyll *a*, phaeophytin, and dissolved oxygen. Additional parameters were added to the routine sampling program for the MOSS project including organics (polynuclear aromatic hydrocarbons, pesticides, polychlorinated biphenyls, and chlorinated herbicides) and total and dissolved metals. The routine and added parameters measured form a solid water quality program and should adequately provide information of use in the siting procedure. Notably absent from the measurements however, are biological samples for phytoplankton, zooplankton and primary productivity. As part of the siting procedure for the marine outfall, productivity measurements were undertaken and are described in separate documents. Reference to these measurements should be made in the water quality report. Monitoring the phytoplankton and zooplankton communities would help address the question of impacts to the system as a result of the outfall. Given the unknown but presumed anthropogenic cause for the increase in harmful algal blooms in coastal waters, measurement of phytoplankton composition and abundance would enhance the program and address long term effects. Although not standard water quality parameters, these variables are frequently included in water quality programs addressing impacts to systems as a result of wastewater treatment.

Several of the tables (example Table 2-3) list the number of measurements taken at each station over the sampling period. However, when I compared the numbers with the data actually present in the Appendices, the actual number of measurements recorded were different. For example – Table 2-3 lists 8 samples for station EDMDS-CTD2 under the general water quality parameters (GWQP) but only 7 are included in the appendix A-2. Similarly, 12 measurements for GWQP are listed for station LTEDO4 but only 11 were included in Appendix A-2. Also I could not find any GWQP data for station KSBPO1 in Appendix A-2, even though 12 measurements were supposed to be taken during 2001. I did not check all entries against the appendices so additional problems of this type might exist. The tables should reflect the actual measurements made not those which were planned.

In general, the parameters being monitored for the MOSS program provide a strong database for use in the siting process. The addition of phytoplankton and zooplankton to the monitoring program, while desirable, is not essential to address water quality concerns arising from a new sewage outfall in Puget Sound.

Measurement methods –Table 2-4 lists the methods used for the various analyses; the table should include references for cited methods, presumable APHA (1992) and EPA (1995). The methods cited are the scientifically accepted and approved methods for water quality analyses. No mention is made in the text of whole water samples being taken for chlorophyll *a*, although samples were taken for nutrients, TSS, bacteria and organics. Presumably the CTD profiler measured in vivo fluorescence, which was calibrated to chlorophyll *a*, using the water sample collected in the Niskin bottles. This should be noted in the report.

Sample design – No explanation is given for the rationale behind the sample design for the water quality component of the MOSS program, in terms of station location, number of stations, depths sampled, sampling periodicity, transects versus discrete stations, beach versus water column stations etc. No explanation is given for the change in number of stations and station location between years. A section needs to be added stating what the goals of the water quality monitoring are in terms of siting a new outfall and how those goals were addressed by the chosen sampling design. The sample program needs to be based on a solid statistical design and be presented in terms of potential outfall sites and effects. This would most easily be accomplished by separating the MOSS water quality program from the routine monitoring program and presenting it as a separate document, cross-referencing the stations in common to both programs. Alternatively, section 2.2 could be expanded and the explanation for the chosen sample design added. I believe, the station locations were specifically chosen for a variety of reasons, such as providing input to models etc.

Data analysis – Data analysis in general is descriptive and lacks synthesis, particularly in reference to siting a new sewage outfall. Again part of the problem may be inclusion of the results from the siting study within a general report on the water quality of Puget Sound. Does the water quality study provide information of use in siting the outfall? Are any sites better then other sites based on the results observed? Attention should be focused on problem periods (i.e. periods of intense water column stratification coupled with high phytoplankton biomass) and/or sites with potentially existing water quality problems (i.e. Elliott Bay and Possession Sound). The overall importance of stratification to the siting procedure needs to be emphasized. The measurements for dissolved oxygen at MOSS beach stations in 2001 indicated extremely low concentrations (<3.1 mg l^{-1}) at 6 stations in July. This is a particularly important finding and should be examined with care, given the importance of nearshore environments to listed species. If there is a relationship between algal growth and decay fueled by added nutrients in wastewater then this needs study.

I also did not find a comparison of the current study with past surveys except in very general terms. Have any of the MOSS sites been previously sampled? Has water quality in general in the Sound changed in recent years? With a database containing 20 years of data, the potential for seeing significant long-term trends should be explored and the results discussed in relation to an additional wastewater treatment facility being built.

One suggestion would be to add a bulleted summary at the end of each section emphasizing: a) how a specific parameter has changed over time; b) how the parameter varies spatially; and c) how the present and past results are useful in siting the outfall. Also some statistical analysis of the existing data should be included: a) are there significant differences among stations or groups of stations; b) has the parameter shown any trend over time; c) are the trends related to wastewater treatment or an expression of natural variability? A statistical analysis of the trace metal data is described as forthcoming, similar analyses should be undertaken for all measured parameters. An enormous amount of data was collected, however the results need to be synthesized and related to potential outfall sites to be useful to decision makers. Without these analyses it is difficult to determine that the data are sufficient to answer the siting criteria questions.

Additionally, the relationship between water quality response variables (ex. chl, DO) and living resources (ex. fish, eelgrass, geoduck) needs to be explored at some point in the text.
In general, I would like to see additional graphs that provide information to managers about the variation among stations in measured parameters and/or relationships among measurements. For example Figure 1, shows the seasonal change in chlorophyll concentration (mg m^{-3}) at a MOSS station (Point Wells) versus an ambient station. Figure 2 shows the relationship between chl *a* (mg m^{-3}) and dissolved inorganic nitrogen (DIN, µM), revealing the inverse relationship between the two variable over an annual cycle.

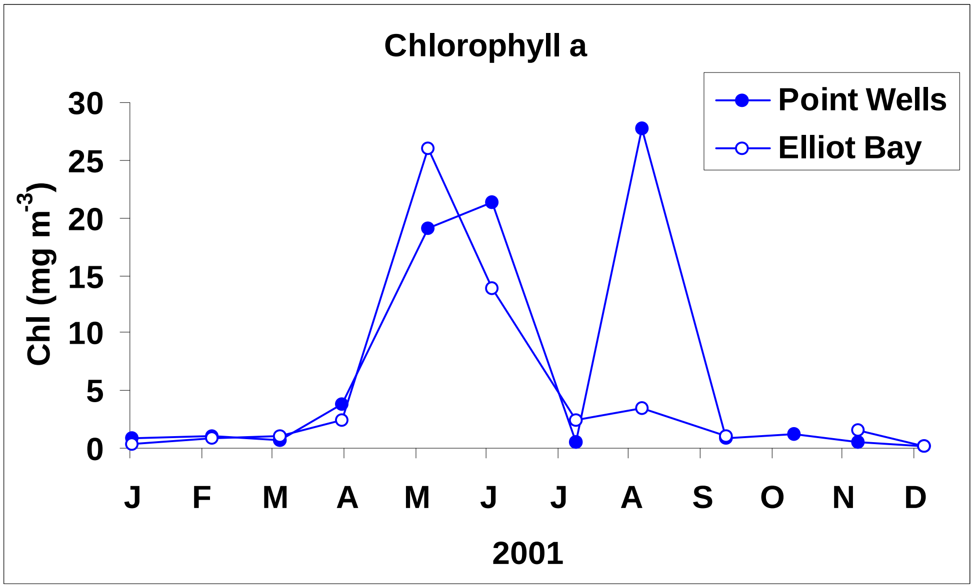


Figure 1. Chl a (mg m^{-3}) in surface waters over the annual cycle at Point Wells and Elliott Bay.

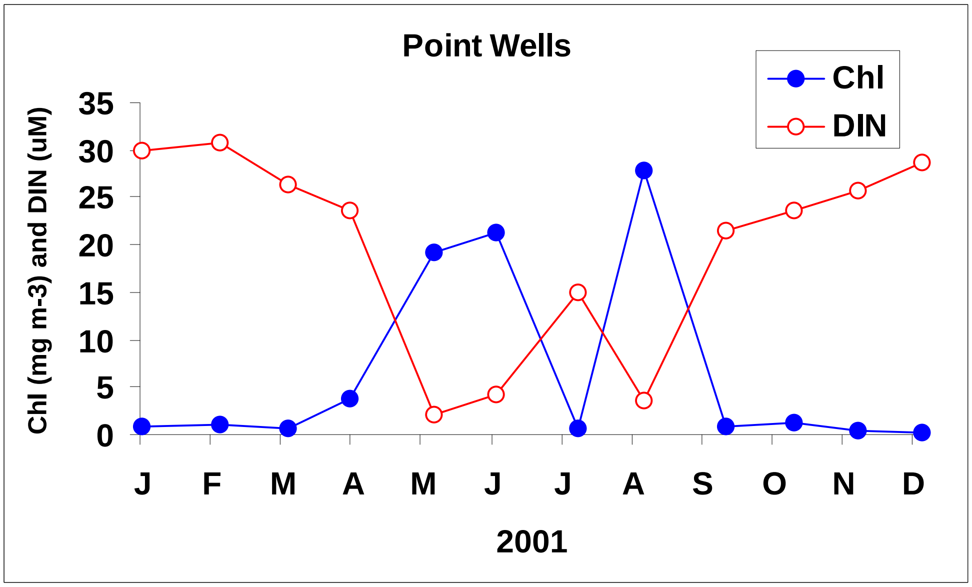


Figure 2. Chl a (mg m^{-3}) and DIN (mM) in surface waters at Point Wells over an annual cycle (2001).

Additionally graphs showing concentrations of nutrients and/or dissolved oxygen concentrations in surface and bottom waters over the annual cycle would help define the periods when stratification is important and nutrient limitation may be occurring (example Figure 3).

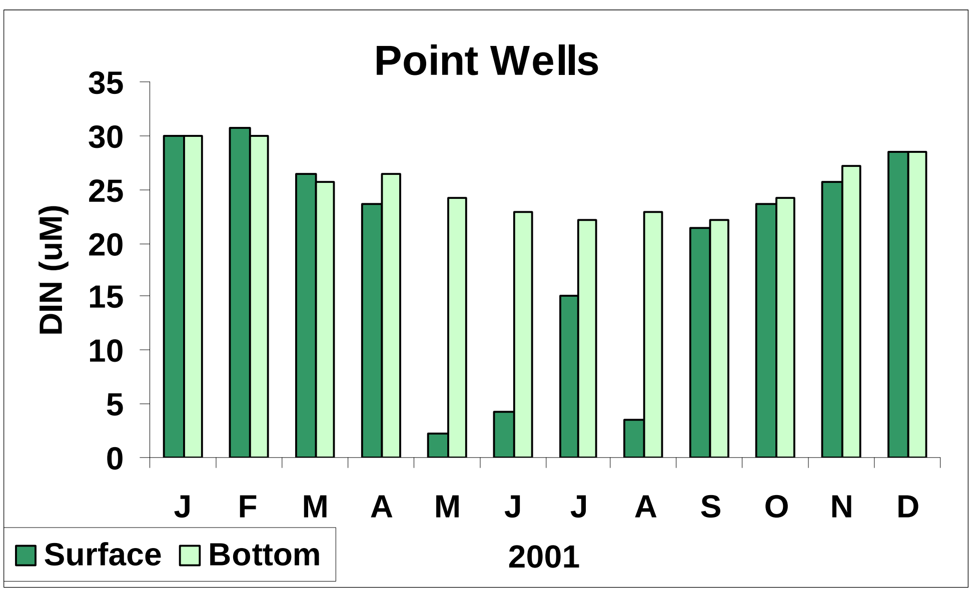


Figure 3. Dissolved inorganic nitrogen (DIN, mM) in surface and bottom waters at Point Wells over the annual cycle.

Summary: Sufficient water quality data have been collected to address questions about where an outfall should be cited to minimize impacts. Methods are approved and acceptable. Report needs to address relationships between results and siting procedure, preferably using statistics. The relationships may change depending on the parameter being examined.

Specific Comments:

Executive summary – page v, paragraph 2, line 1. Change 'County is plans' to 'County plans'

Executive summary -page vi, Paragraph 3, line 3. *E. coli* is mentioned for the 1st time and should be called *Escherichia coli*, this does not happen until section 2.3.1 page 2-12..

Executive summary -page vii, Paragraph 2, line 7. There are two periods at the end of the sentence.

Page 2-5. Table 2.2. Station CK200P, Water parameter GWQP is listed as being measured 12 times but only 11 dates are included in appendix A-1 (12 measurements are given for bacteria, Appendix A-5); 12 GWQP measurements are listed for VO50E but only 10 given in Appendix A-1. Station LTBC41 is listed as a nearshore point source station in Table 2.2 but the results are included in Appendix A-1 which is described as an appendix for offshore samples.

Page 2-6. Section 2.1.2. Paragraph 1. A long-term data set (20 years) is described, yet no long-term results are seen in the report. A few variables should be followed long-term and appear as graphs to illustrate changes in water quality in the Sound over time.

Page 2-7. Figure 2-2. Station KSBP01 is shown in the figure and mentioned in Table 2-3 but I can not find the data in the appendices. Have I missed it?

Add rationale for sample design to this section

Page 2-9. Section 2.2.1, paragraph 1, line 6 – Nutrient abundance should be nutrient concentration.

Paragraph 2, line 2-3. Give figure number (figure 4-1) rather than saying a figure appears in section 4. Perhaps the figure should be moved to section 2.

Page 2-11, Section 2.2.2. line 9. Nutrient abundance should be nutrient concentration.

Page 2-12. Section 2.3.1. Paragraph 2 – The presence of viruses and toxic dinoflagellates are mentioned as not being detectable by the fecal coliform method and reference is made to separate collection of these data as a necessity – I could not find any additional reference to whether these variables are ever measured.

Page 2-13. Section 2.3.3. Define hypoxic as a specific concentration of DO. Relate known low DO concentration to known effects.

Page 2-14. Section 2.3.5. diatoms are phytoplankton and should not be separated out as done in line 5.

Page 2-15. Section 2.3.7. Throughout the text phaeophytin is spelled as "pheophytin" however in Table 2-4 and in data appendices it is spelled as "phaeophytin". I have always used phaeophytin but believe either spelling is accepted???? But consistency is important.

Page 2-16. Section 2.3.9. No mention is made of collecting chl samples from the Niskin bottles but this must be done to calibrate the in vivo fluorescence measurements.

Subsection Laboratory Methods – pg 2-16. A reference is cited as (APHA 1995). The reference is listed as 1992 in the literature cited section.

Section 2.7 Regulatory standards – include a section and table for DO. Include a table showing EPAs heavy metal tissue-residue standards – referred to in section 2.7.4

Section 3.2.1. The discussion on enterococcus bacteria would benefit from a seasonal plot or a plot of abundance versus rainfall to demonstrate the lack of correlation between the two measurements. Results should be summarized by station in a table showing mean, max, min, std, se or similar statistics, similar to the tables in the trace metals section. Logarithmic plots are often used for presenting bacteria counts.

Page 3-18. Section 3.2.4. Figures 3-16 and 3-17 are reversed, i.e. the text refers to figure 3-16 but is describing 3-17 and vice versa.

Page 3-20. Figure 3-17. The symbol for October is impossible to see and out of order in the legend.

Page 3-22. Section 3.2.6. Ammonia. Line 8. Text suggests that ammonia is generally highest when phytoplankton concentrations are high. Phytoplankton was not measured and the relationship between chl and DIN is inverse (see figure 2, above).

In general I would like to see some plots showing nutrient concentrations on a seasonal basis, variation among stations and differences between surface and bottom concentrations rather than representative profiles for 6 stations.

Page 3-29. Section 3.2.7. Where are the results showing the use of pH to compare measured ammonia concentrations to the criterion? pH does vary in estuarine offshore waters and perhaps it should be measured in Puget Sound.
Final line. Change 'there was no data' to 'there were no data'

Section 3.2.8 Seasonal plots of surface, bottom or depth averaged chl should be shown. I did like the addition of table 3-6, as a summary table.

Section 3.2.8 through Section 4 were more informative and did a better job of summarizing data but also need to be tied to the potential outfall sites.

Page 4-4. Section 4-5. The transect data and the water column monitoring data should be cross-referenced. The chl concentrations seem much higher in the transect data and the text suggests that a second bloom may occur at Point Wells later in the year, while the monitoring data show that it did, in fact, occur.

Page 4-5. Section 4.6. Paragraph 1, line 9. Figures is misspelled as 'fisgures'. More importantly, the DO transects should include the time of the year when DO is seasonally low. Why were samples not collected then??????

In general, it seems like a lot of effort went into generating transect data and producing the graphs but little went into interpretation, particularly with regards to siting an outfall.

Appendix A-1. The actual light with depth data should be included in the appendices, as well as the % of surface light so that extinction coefficients and the depth of the 1% layer can be calculated by interested readers.

Appendix Table A-2. Page A-30. The dates for the February and March samplings at station PTWELLS1 are not shown in the Table.

Page A-33. The date Dec 17, 2001 is repeated 2xs for the PTWELLS1 station. (also on page A-34).

END OF KELLER FULL TEXT REVIEW

Review of Physical Oceanography documents for King County Brightwater Project

February 24, 2003

Reviewer:

Parker MacCready, Ph.D.
Associate Professor
University of Washington
Oceanography, Box 355351
Seattle, WA 98195-5351
Phone: (206) 685-9588 (UW), (360) 956-3216 (Olympia)
Email: parker@ocean.washington.edu

Documents reviewed:

1. Water Quality Status Report for Marine Waters, 1999 and 2000 (Partial review only)
2. Water Quality Status Report for Marine Waters, 2001 (Partial review only)

I will limit my comments on these reports to simple physical properties such as salinity, temperature and density. In general these are standard data reports, with little interpretation offered (as is typical and reasonable).

The main issue I found here had to do with data presentation. In the CTD section data, presented in Section 4 of both reports, I would have liked to see the data plotted in an along-channel format, instead of just separate cross-channel sections. This would involve choosing a station from each section (probably the first one off of the east shore that was in more than 100 m of water) and then putting these together into a new along-channel section stretching from Alki to Possession Sound. If the timing of the sections is such as to add too much aliasing into such a composite section, then perhaps the experimental design might be rethought. What I am looking for here is a graphical sense of what the along-channel density structure is between Pt. Wells and Possession Sound. The motivation for wanting to see this is that the current meters in Doc. 3 suggested that sometimes there was a northward flow path of mid-depth water between Pt. Wells and Possession Sound. However, it also appears that the inflow into Possession sound might take place somewhat higher in the water column than the northward flow at Pt. Wells. It could be that isopycnal surfaces at mid-depth slope upwards between Pt. Wells and Possession Sound, and if this were the case then there would be more reason to suspect that the flow pathway there might be changing depths (shoaling to the north) as well. This could be a basis for making an updated version of Figure 3B from the Review (Doc. 1).

Related to this, I would have liked to see an additional section farther north in Possession Sound. This is prompted by the progression toward lower DO water apparent in Fig. 10 of the Review

(Doc. 1). Does water quality in Whidbey Basin follow properties in Main Basin, or does it develop independently?

These are difficult questions to answer, but would be reasonable tasks for the next generation of 3D modeling. In any case, I found the data presentation of the CTD sections to be somewhat uninformative. At the very least some more contour lines could be added judiciously so that deep water properties could be discerned. A common technique used in the blue-water oceanographic literature is to split a section into two panels, one of which covers just the top, highly stratified, layer.

END OF MACCREADY FULL TEXT REVIEW

Reviewer: Michael Mickelson

Documents Reviewed:
1. Water Quality Status Report for Marine Waters, 1999 and 2000
2. Water Quality Status Report for Marine Waters, 2001

Introduction

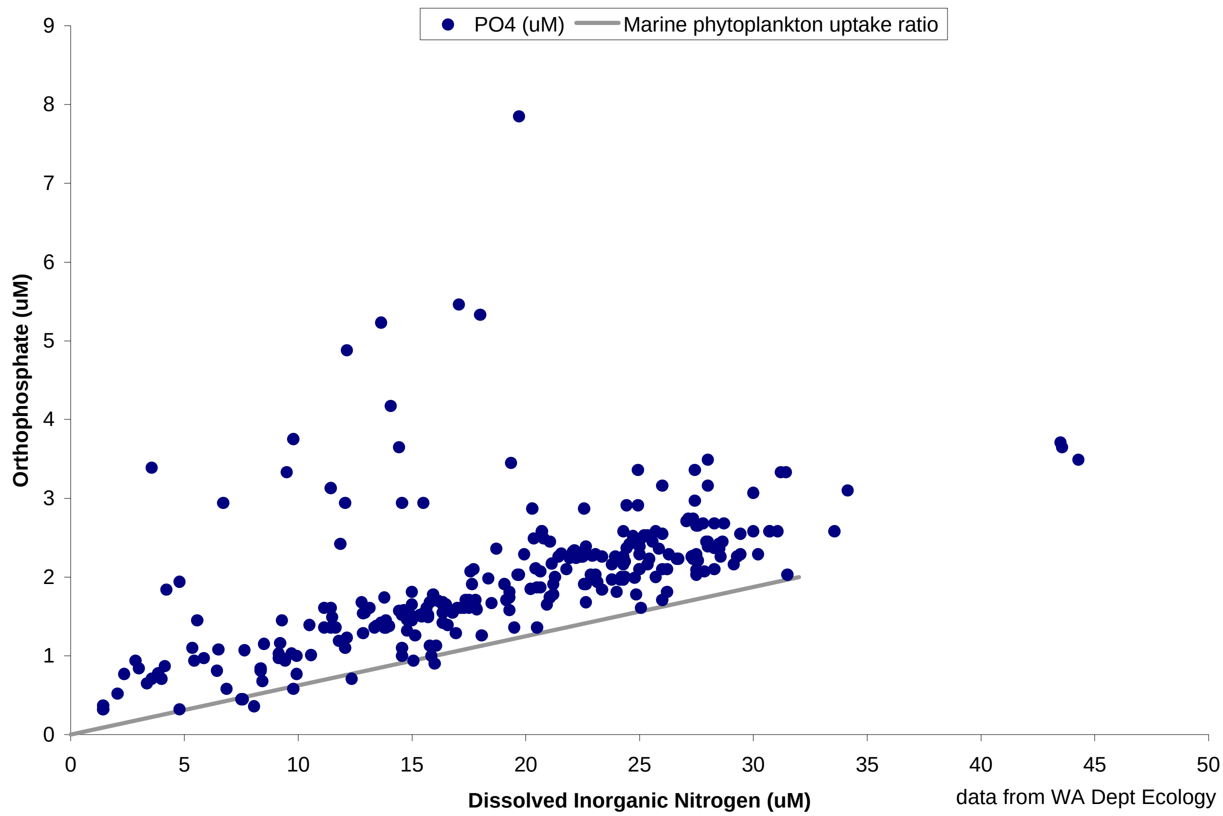
It is clear from the reports that outfall siting is not critical: many possible locations would be OK. Evidence for this is:
1. The monitoring programs barely detect any signal at all from the existing outfalls, whether in nutrients, toxics, or pathogen indicators.
2. the effluent load is tiny compared to natural loads.

Point Wells looks particularly good in relation to northerly currents and flushing, and we have to be imaginative to even discuss any adverse effects. For example:
1. Possession Sound is considered unsuitable for an outfall. There is some similarity however in the salinity patterns of Possession Sound and Point Wells. Does that imply "communication" of waters? Is that an issue?
2. There are a few data points which show the ammonium and salinity signature of the South system outfall. The plume may even be surfacing. Is this an issue?
3. Plume surfacing and dilution are critical topics covered in other reports. I mention it here because from my assigned reports 1 and 2, I am struck how weak stratification is much of the year, so the plume may tend to surface.
4. The monitoring stations chosen give a somewhat optimistic view of Puget Sound. Newton et al. (2001) presents a wider view of the Sound as a whole and you can see the real problem areas – where one might not want to site an outfall. Despite the presence of serious problems, the Sound is big and under the influence of such big processes that the Brightwater outfall won't make a dent in it.

Looking toward future monitoring let me offer an impression that the monitoring program managers could review their goals, possibly leading to:
1. A management decision to either choose methods which detect what is being measured, or provide an explicit explanation in the work plan of why it is responsible to merely provide an upper bound to a value with a nondetect rather than to know the actual number.
2. Clarifying the monitoring responsibilities of King County to balance a restricted focus on testing for evidence of exceedance of criteria versus evaluation of patterns and processes.
3. Recognition of information gaps such as how local change in nutrients is related to offshore waters versus seasonal sinking to sediments.

General Comments
You don't measure orthophosphate because N rather than P limits in marine systems. The chart below shows that your assumption is OK, though phosphate can get low at times as well.

Nitrogen versus phosphorus limitation
West Point Outfall site PSB003

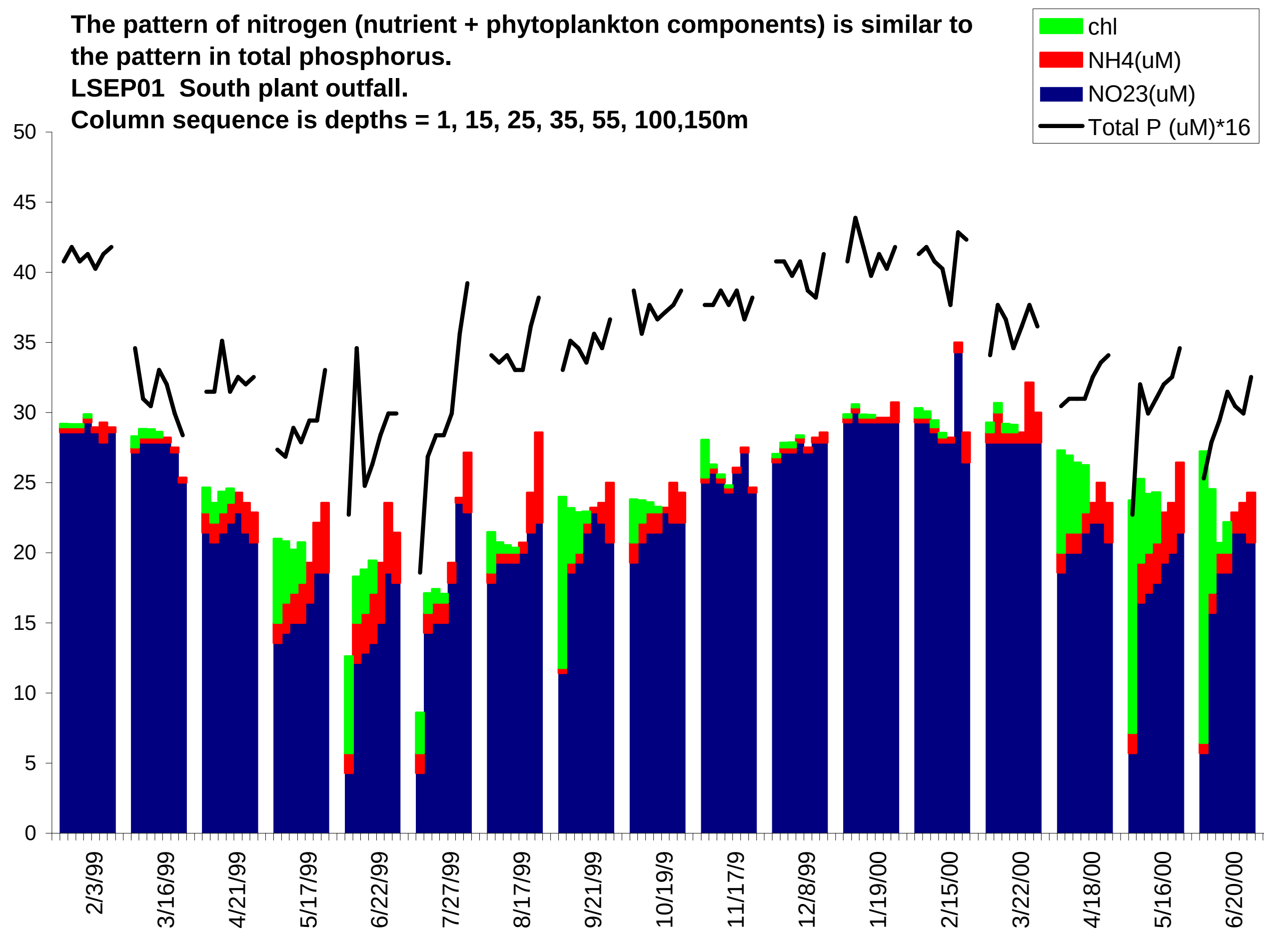


I was impressed how high the nitrate concentrations are. Also there is such a clear relation between chlorophyll and the deficit in nitrate compared to winter values, except that it does not balance in summer – either particulate nutrients are sinking and being stored in the sediments (but it is so deep), or the offshore nitrogen has that same seasonal pattern. No doubt this has been studied, but I wanted to see what the data at hand reveal.

The monitoring program only measures a few nutrient forms but one can make a crude nutrient balance as in the chart below:

Assumption 1: 1 ug chl m-3 is equivalent to 1 uM dissolved inorganic nitrogen.
Assumption 2: Total phosphorus *16:1 is equivalent to total nitrogen + a constant
Assumption 3: neglect DON for convenience.

The stacked bars are the sum of NO23 + NH4 + chlorophyll-nitrogen. The line showing Total P matched the top of the stacked bars plus a constant.



The chart shows that there is a lot of nitrate all year long, but the nitrate is reduced in surface waters in summer and the deficit shows up as chlorophyll. There is also a contribution from ammonium, a little more in bottom waters. Surface waters have less total N and less total P (7/27/99). If the summer decline in total nutrients was due to advection, there would be no decrease in surface waters. This is a crude example – is this kind of thinking consistent with the goals of monitoring?

The effluent load of nitrogen is small compared to the load from offshore. A crude calculation is that 200 outfalls would just match the load from offshore: although the effluent concentration may be 50 times that of ocean water, the effluent flow is only about 0.01% of tidal exchange (assuming 10% rectification) so the load from Brightwater would be 0.5% of the offshore load. Baywide you could not detect an 0.5% increase in chlorophyll. Cokelet et al. (1991) may have better numbers.

The strongest outfall signal seen was at West Point outfall (KSSK02) on 6/19/01 where ammonium was 0.28 m/L. That corresponds to about 50:1 dilution: [(.28-.05)*100/14*1/800 = 0.02 = 1/50]. The South system outfall (LSEP01) had little outfall signal. There was no phosphate data to support the ammonia observation. Other reports may deal with plume size and shape.

Specific Comments

Changes in chlorophyll. Why not include satellite imagery in the reports to show the extent of blooms?

Pycnocline tilt. Is the apparent tilt in the pyncocline an artifact due to the time it takes to complete the survey in relation to the tidal cycle?

Suggestion: when discussing low DO concentrations also mention the percent saturation. Example page 3-18 DO is 5.1 mg/L but it is helpful to also know that DO is 57% of saturation [LTED04 22-Aug-01 T=11.7 S=30.662]

Suggestion for Figure 4-1: use a log color scale for PAR irradiance.

Summary

The baseline is solid.

Suggestion: The goals of the monitoring should be reviewed and stated as clearly as possible to balance effort to detect the outfall signal versus effort to chronicle natural variability.

References

Cokelet, E. D., R. J. Stewart, and C. C. Ebbesmeyer, 1991: Concentrations and ages of conservative pollutants in Puget Sound. Puget Sound Research '91, Vol. 1, Puget Sound Water Quality Authority, 99-108.

Newton JA, S.L. Albertson SL, Van Voorhis K, Maloy C, Siegel E. 2001. Washington State Marine Water Quality 1998 through 2000. Washington State Department of Ecology, Environmental Assessment Program, Publication # 02-03-056, Olympia, WA.

<u>END OF MICKELSON FULL TEXT REVIEW</u>

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

Michael Connor

***Questions from the 1999-2000 report*:**

From the full text review- referring to Executive Summary:

1. The phytoplankton bloom observations are left without context. Can the timing of the bloom this year be explained by light, nutrients, or timing of stratification?

Respondent: Kim Stark, King County DNR:

> *RESPONSE: The difference in timing of the late summer/fall blooms cannot be explained entirely by stratification, light or nutrients--a thorough evaluation of other weather conditions, wind and rain, would be necessary however time did not permit a thorough evaluation of the data.*

2. The organics data also lack context. If there are no standards and no comparisons to other areas or other standards, why bother collecting this information?

Respondent: Scott Mickelson, King County DNR:

> *RESPONSE: These data had never been collected before in the Puget Sound water column and were needed for baseline water quality information, both for the outfall project and the County's habitat conservation plan. There are some WQ criteria for organic compounds, limited to pesticides and PCBs, neither of which were detected over the course of the study. Our detection limits generally meet the acute WQ criteria, however, exceed several of the chronic criteria.*

***Questions from the 2001 report*:**

From the full text review- referring to Figures 3-4/5 (page 3-8):

1. Wouldn't this graph be more relevant as a frequency histogram on the y-axis? The x-axis has an odd mixture of bins for scale. It might make more sense to do a log-transform.

Respondent: Kim Stark, King County DNR:

> *RESPONSE: Good point.*

From the full text review- referring to Figure 3-9/10/11 (pages 3-11/12):

1. Why not present this as a regression?

Respondent: Kim Stark, King County DNR:

RESPONSE: The thought was to present the data so the general public would be able to understand and try not to overload the report with too many statistics. It's hard to obtain the right balance for the appropriate level of detail for both scientific and general public users.

From the full text review- referring to Figure 3-25 (page 3-30):

1. Any correlation between pH and chlorophyll?

Respondent: Kim Stark, King County DNR:

RESPONSE: We didn't measure chlorophyll at the beach stations.

From the full text review- referring to Table 3-17 (page 3-51):

1. Isn't the TOC and %OC the same number? Yes. Why show this conversion?

Respondent: Kim Stark, King County DNR:

RESPONSE: Some people prefer to see the number in % and others prefer mg/Kg so we provided both to avoid user calculation errors.

From the full text review- referring to Section 3.4.1 (page 3-54):

1. Why graph percentage lipids? Isn't it just natural variability?

Respondent: Kim Stark, King County DNR:

RESPONSE: Yes and this won't be graphed again!

From the full text review- referring to Section 3.4.3 (page 3-55):

1. Benzoic acid also showed up in the baseline sediment study. Could there be a lab contamination issue?

Respondent: Kim Stark, King County DNR:

RESPONSE: We expect to find high levels of benzoic acid in the clams since it's a metabolic byproduct. We would be very concerned if there were no detections and would have the lab obtain a new sample.

From the full text review- referring to Section 3.4.4 (page 3-58):

1. I found the discussion puzzling. Why not present a regression plot?

Respondent: Kim Stark, King County DNR:

RESPONSE: I agree, this discussion is confusing. Good point.

From the full text review- referring to Section 3.5 (page 3-59):
Respondent: Kim Stark, King County DNR:

There was some suggestion of trends in the macroalgae data results. The reader would like the report to answer the questions:

1. Are the point-source stations elevated? *Not addressed.*
2. Are the point-source stations all equivalent? *Not addressed.*
3. Are the reference stations truly unimpacted? *Not addressed.*
4. Do the areas with high metals correspond to the local loadings? *Not addressed.*
5. Do the algae levels correspond with the water column measurements?

Good point to address for the next report.

Aimee Keller

***Questions from the 1999-2000 report*:**

1. Does the water quality study provide information of use in siting the outfall?
2. Are any sites better than other sites based on results observed?

Respondent: Scott Mickelson, King County DNR:

RESPONSE: As far as selecting a particular site, no. There were few spatial differences in either metal or organic concentrations in the marine water column. The metals and organics study was performed mainly to evaluate baseline conditions in Puget Sound – data that had not previously been collected. This study also served to collect receiving water data for the County's habitat conservation plan. An additional, focused study is currently being undertaken (with some lowered detection limits) to specifically target purported endocrine disrupting compounds.

3. Is water quality really so high that eutrophication within the basin is non-existent? In many cases the answer to this question appears to be yes – but this needs to be clearly supported.

Respondent: Kim Stark, King County DNR:

RESPONSE: Water quality data at stations monitored indicates a high level of water quality when compared to current Washington State surface water quality standards.

4. I also did not find a comparison of the current study with past surveys except in very general terms. Have any of the MOSS sites been previously sampled? Has water quality in general in the Sound changed in recent years?

Respondent: Kim Stark, King County DNR:

> *RESPONSE: Sampling at the MOSS sites began in 1999. Water quality data at stations monitored for the past several years show little change for parameters measured. At some sites, there is a 30-yr dataset that shows no change.*

From the full text review- referring to Section 3.2.6:

1. Why was a standard temperature of 15°C, salinity of 30 ppt and pH of 8.0 used to calculate the ammonia criteria rather than the actual temperature, salinity and pH at the times and locations where samples were collected?

Respondent: Kim Stark, King County DNR:

> *RESPONSE: We use the EPA Total Ammonia conversion table to derive the total ammonia standard. This chart has salinity categories of 10, 20, and 30 pss. The chart also has temperatures in 5 degree increments and pH in 2 increments. We do not routinely collect pH data for offshore waters since there is little variation and data collected indicates a pH of 8.0 is typical. We use 15, 30, and 8.0 as these numbers are closest to measured values.*

From the full text review- referring to Appendix F-2:

1. Why is no bottom depth shown for the Lake WA Ship Canal?

Respondent: Kim Stark, King County DNR:

> *RESPONSE: This is not a MOSS station, however, only surface samples are collected here.*

***Questions from the 2001 report*:**

From the full text review- referring to Figure 2-2 (page 2-7):

1. Station KSBP01 is shown in the figure and mentioned in Table 2-3 but I cannot find the data in the appendices. Have I missed it?

Respondent: Kim Stark, King County DNR:

> *RESPONSE: No--it turns out pages A-19--A-22 are missing from the hardcopy. A copy of the missing pages will be provided*.

From the full text review- referring to Section 3.2.7 (page 3-29):

1. Where are the results showing the use of pH to compare measured ammonia concentrations to the criterion? *On page 3-24 in the ammonia section*. pH does vary in estuarine offshore waters and perhaps it should be measured in Puget Sound.

Respondent: Kim Stark, King County DNR:

> *RESPONSE: pH was measured during one sampling cycle in offshore waters and it was determined that it need not be sampled further as additional results would not provide added benefits and did not appear necessary to aid in interpreting results from other parameters.*

From the full text review- referring to Section 4.6 (page 4-5):

1. The DO transects should include the time of the year when DO is seasonally low. Why were samples not collected then?

Respondent: Scott Mickelson, King County DNR:

> *RESPONSE: They were – August through October.*

Parker MacCready

1. Does water quality in Whidbey Basin follow properties in Main Basin, or does it develop independently?

Not addressed.

Michael Mickelson

1. Possession Sound is considered unsuitable for an outfall. There is some similarity however in the salinity patterns of Possession Sound and Point Wells. Does that imply "communication" of waters? Is that an issue? *Not addressed.*

2. There are a few data points that show the ammonium and salinity signature of the South system outfall. The plume may even be surfacing. Is this an issue?

Respondent: Kim Stark, King County DNR:

> *RESPONSE: Ammonia is the only parameter where a signature from either of the two main outfalls can be detected. For the South Plant outfalls, this signature can be seen at depth, near the PLUMES predicted trapping depth, but there does not appear to be evidence that the plume is surfacing for either ammonia or salinity.*

3. Is the apparent tilt in the pyncocline an artifact due to the time it takes to complete the survey in relation to the tidal cycle?

Respondent: Kim Stark, King County DNR:

> *RESPONSE: Good question! The amount of time it takes to complete an entire sampling run may cause slight differences but it's not likely and the pycnocline tilt is more pronounced at those stations that have a strong freshwater layer influence.*

From the full text review- referring to the second graph in the review:

1. Surface waters have less total N and less total P (7/27/99). If the summer decline in total nutrients was due to advection, there would be no decrease in surface waters. This is a crude example – is this kind of thinking consistent with the goals of monitoring?

> *RESPONSE: I'm sorry but I don't understand this question.*

Document 3: *Geoduck Tissue Study, Brightwater Candidate Marine Outfall Zones, Sampling and Analysis Plan. April 2002*

Coordinator's Summary

Both peer reviewers examined the entire technical document, and provided comments independently.

Michael Mickelson: Chemistry comments

The study design was "generally OK" but the "nutrient and organic methods [were] inadequate for determining a baseline." The reviewer presented numerous questions addressing the purpose of the study, data quality objectives, and data analysis. These questions, as well as the answers provided by the MOSS team, are listed in the final pages of this summary.

Insensitive analytical methods were used for organics. For example, "the method detection limit for phenanthrene [was] 450 times that used" in another study. Lastly, testing for "statistical interactions" would not be possible when collecting "only one organism per station" (i.e., no replicates).

Recommendations: 1) "Relate the methods and results to national monitoring (NS&T) –[see link below]. Consider extending the national monitoring rather than NS&T study."

Michael Connor: Ecology comments

The sampling and analysis plan was "clear and well written" and summarized the methodologies completely. However, the data quality objectives "were vague as to how the results would be used" to assess contaminant concentrations in the proposed outfall zones. For example, "the human health guidelines for PCBs might require lower detection limits than those proposed." Finally, data requirements for a Biological Assessment should be stated explicitly.

Recommendations: None

Document 3: *Geoduck Tissue Study, Brightwater Candidate Marine Outfall Zones, Sampling and Analysis Plan. April 2002*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Reviewer: Michael Mickelson

Documents Reviewed:
Geoduck Tissue Study, Brightwater Candidate Marine Outfall Zones, Sampling and Analysis and Plans

General Comments

The study design is generally OK.

Recommendation: relate the methods and results to national monitoring (NS&T). Consider extending the national monitoring rather than NS&T study

Specific Comments

Page 1: One purpose of the study was to evaluate bioaccumulation in long-lived organisms. In what way did the long lifespan of the test organism affect the study design? Do they depurate? Wouldn't an ideal test organism integrate its contaminant exposure over a few months and certainly not much longer than a year? It is not clear why you use geoducks.

Page 1: One purpose of the study is to detect potential human health impacts. How is this relevant given that geoduck fishing is banned at the sampled locations?

Page 3: One data quality objective is to evaluate concentrations of organic compounds. Is this DQO met when the methods are not sensitive enough to measure the concentration?

Page 3: Section 4.3.1 Precision, Accuracy, and Bias. This page describes the importance of field replicates, but the later sections of the report do mention field replicates.

Page 4: Section 4.5 Data Analysis. Data analysis will compare metals results to FDA criteria. Why not also compare results to criteria for organics? [e.g. Total PCB 2000 (ng/g wet wt.); Total DDT 5000 (ng/g lipid); Total Chlordane 300 (ng/g lipid); Dieldrin 300 (ng/g lipid)]

Page 4: Section 4.5 Data Analysis. How will you analyze the data to improve your ability to detect change due to the outfall?

Page 5: The work plan does not specify the container for organisms. The field study suffered from contamination in part because adequate containers were not provided.

Page 7: The Analytical methods for organics are not sensitive. For example the method detection limit for phenanthrene is 450 times that used by Lefkovitz et al. (2002). The more sensitive method is not more expensive (in bulk) but it does measure fewer contaminants (Steve Rhode pers. comm.). I looked at Seiders and Yake (2002) but didn't find much detail.

Study	Method Detection Limit for Phenanthrene (ng/g dry weight)
King County 2002. (Table 16 says ug/Kg wet weight * (10g wet/1g dry) = 160 ug/Kg dry weight = 160 ng/g dry weight.	160
Lauenstein and Cantillo (1988). Page 4	5.5
Lefkowitz (et al.). Table 12	0.351

Appendix page 6. Only here is it clear that you will collect only one organism per station. Without replication you will not be able to test for statistical interactions (depth*location).

Appendix page 6. You will not select organisms by age or size. What are the statistical consequences of having a 3-way (location, depth, age) unbalanced (age is not controlled) design without replication (one organism per location*depth)?

Summary
The nutrient and organics methods are inadequate for determining a baseline.

References

King County. 2002. Geoduck Tissue Study Sampling and Analysis Plan. Seattle: King County Department of Natural Resources and Parks.

Lefkovitz L, Abramson S, Hillman R, Moore M, and Field J. 2002. 2001 annual fish and shellfish report.
Boston: Massachusetts Water Resources Authority. Report ENQUAD 2002-14. p. 175.

Lauenstein GG, Cantillo AY (Editors). 1998. 1998 Sampling and Analytical Methods of the National Status and Trends Program Mussel Watch Project: 1993-1996 Update - Technical Memorandum 130. http://ccmaserver.nos.noaa.gov/Pdfpubs/techmemo130.pdf

Seiders, K. and W. Yake. 2002. Quality Assurance Project Plan: Washington State Toxics Monitoring Program, Exploratory Monitoring of Toxic Contaminants in Edible Fish Tissue and Freshwater Environments of Washington State.

1998 Sampling and Analytical Methods of the National Status and Trends Program Mussel Watch Project: 1993-1996 Update - Technical Memorandum 130.
http://ccmaserver.nos.noaa.gov/Pdfpubs/techmemo130.pdf

END OF MICKELSON FULL TEXT REVIEW

Reviewer: Michael Connor

Document	Geoduck Tissue Study, Brightwater Candidate Marine Outfall Zones,Sampling and Analysis Plans
General Comments	This report provides a complete summary of the methodology used for geoduck population assessment and tissue analysis. It is clear and well-written. My only concern was that the data quality objectives were vague as to how the results would be used to "evaluate concentrations of [contaminants]…and assess spatial variations of these concentrations within the candidate outfall zones." For instance, the human health guidelines for PCBs might require lower detection limits than those proposed. In addition, the Appendix (p.2) indicates that the data wll be used to support an Endangered Species Act Biological Assessment. It would have been useful to determine very explicitly those data needs.
Specific Comments	
Sec 4.4 p.5	Table 2 indicates what must be generic holding times. Later the report promises 90 day delivery. It's a bit confusing as to what is actually proposed
Summary	On the whole, this report is very clear and complete.
References	None.

END OF CONNOR FULL TEXT REVIEW

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

Respondent: Scott Mickelson, King County DNR

Mike Mickelson

General Questions:

1. One purpose of the study was to evaluate bioaccumulation in long-lived organisms. In what way did the long lifespan of the test organism affect the study design? Do they depurate? Wouldn't an ideal test organism integrate its contaminant exposure over a few months and certainly not much longer than a year? It is not clear why you use geoducks.

> *RESPONSE: Geoducks were chosen as a test organism mainly because they are a species of interest from a commercial, economic, and political standpoint. The ability to evaluate chemical concentrations in "long-lived, sessile organisms" was secondary to the study.*

2. One purpose of the study is to detect potential human health impacts. How is this relevant given that geoduck fishing is banned at the sampled locations?

> *RESPONSE: There is a great deal of pressure from the tribes to open as many geoduck tracts as possible to harvesting and they have been successful recently in getting some tracts re-opened.*

From the full text review- referring to page 3:

1. One data quality objective is to evaluate concentrations of organic compounds. Is this DQO met when the methods are not sensitive enough to measure the concentration?

> *RESPONSE: Stating that the "methods are not sensitive enough to measure the concentration" is based upon the assumption that all or most of the organic compounds are present in these tissue samples at some level below our detection limits, which is not a valid assumption. As a baseline characterization of geoduck tissue, all DQOs were met.*

From the full text review- referring to Section 4.5 (page 4):

1. Data analysis will compare metals results to FDA criteria. Why not also compare results to criteria for organics? [e.g. Total PCB 2000 (ng/g wet wt.); Total DDT 5000 (ng/g lipid); Total Chlordane 300 (ng/g lipid); Dieldrin 300 (ng/g lipid)].

> *RESPONSE: This data analysis procedure was inadvertently omitted from the SAP but was done during data review, however, none of the compounds was detected so data analysis was merely comparing MDL values to FDA guidance criteria.*

2. How will you analyze the data to improve your ability to detect change due to the outfall?

> *RESPONSE: It's unclear if we will again monitor geoduck tissue as part of ongoing outfall operations. This will depend largely on pressure from the tribes to open the geoduck fishery in this part of Puget Sound.*

From the full text review- referring to Appendix (page 6):

1. You will not select organisms by age or size. What are the statistical consequences of having a 3-way (location, depth, age) unbalanced (age is not controlled) design without replication (one organism per location*depth)?

> *RESPONSE: This was not our choice of sampling design as the tissue study was secondary to the population study and we wanted to minimize the number of geoducks that were taken for tissue analysis. I don't believe we would want an "age-controlled" sampling design because this would not reflect a real-world scenario, in which geoducks would be harvested.*

Mike Connor

No Questions.

Document 4: *Brightwater Marine Outfall: Geoduck Tissue Study Final Report. November 2002*

Coordinator's Summary

Both peer reviewers examined the entire technical document, and provided comments independently.

Michael Mickelson: Chemistry comments

The baseline data "for metals in geoducks [were] adequate, but not for organics." For example, "many of the results for organics were below the detection limit." Moreover, the results for metals and not organics were compared to the regulatory criteria. Also, field replicates were not used "to evaluate the precision of methods."

The reviewer presented several questions addressing data analysis and methods. These questions, as well as the answers provided by the MOSS team, are listed in the final pages of this summary.

Some relationships between variables were discussed (e.g., mercury increasing with age) but others were not mentioned (e.g., "weight declines with depth"). Finally, "explicitly recognizing relations between contaminants, tissue type…,depth, and age could increase the power to detect change due to the outfall."

Recommendations: 1) "Abandon the study unless you can use better organic chemistry methods;" and 2) "calculate the detectable change. If that is inadequate, revise the study or abandon it."

Michael Connor: Ecology comments

The document provided a solid baseline, and in general "the chemical methodology, organismal handling, and quality assurance [were] carefully done and clearly reported." Detection limits should be "carefully considered" to ensure "compliance with human health guidelines."

Contamination due to increased sample handling necessitates re-evaluating the methodology. The reviewer plotted benzenehexachloride (BHC) versus geoduck age that displayed a "hint of correlation." Future monitoring efforts could benefit from developing a "target size range for clams picked for analysis."

Recommendations: 1) "Because of the evidence of the relationship between size and tissue concentration for at least mercury, …future studies [should] constrain the size of animals collected;" and 2) King County should "evaluate using the 'new' EPA method 1668 for the PCB congeners."

Document 4: *Brightwater Marine Outfall: Geoduck Tissue Study Final Report. November 2002*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Reviewer: Michael Mickelson

Documents Reviewed:
Geoduck Tissue Physical Characteristics, Microbiology, and Chemistry: Geoduck Tissue Study for the Brightwater Candidate Marine Outfall

General Comments

The study is useful but it is a shame to use insensitive methods.

Specific Comments

Lessons were learned about contamination and survey preparation.

The herbicide analyses failed. Have others measured it successfully? Why do you think this is worth measuring? (I wouldn't know)

Four of the nine stations do NOT have unique coordinates (Table A-1; Fig 1) even though they have different depths. Is this a typo or a steep cliff face?

The report described some of the relations between variables, such as how mercury increases with age, but doesn't mention others such as weight declines with depth, solids decline with age, and As Cd Cr increase with age. This is more than a curiosity. Explicitly recognizing relations between contaminants, tissue type (whole or edible), depth, and age could increase the power to detect change due to the outfall.

Error? The Pb-lead data for GDK7S-1W seem low for whole tissue and for GDK7S-2E seem high for edible tissue.

There were no field replicates to evaluate precision of methods.

Regulatory criteria were compared only to results for metals, not organics.

Many of the results for organics were below the detection limit. The study should not be repeated without reconsidering the choice of analytical methods. Given the industrial past of Point Wells, would you expect to detect oil contamination with more sensitive methods? If so, that might be important baseline information.

What does Musselwatch say about Puget Sound? Wasn't there a lot of oil pollution?

Summary

The baseline for metals in geoducks is adequate, but not for organics.
Recommendation: abandon the study unless you can use better organic chemistry methods.
Recommendation: calculate the detectable change. If that is inadequate, revise the study or abandon it.

References

None

END OF MICKELSON FULL TEXT REVIEW

Reviewer: Michael Connor

Document

Geoduck Tissue Physical Characteristics, Microbiology, and Chemistry: Geoduck Tissue Study for the Brightwater Candidate Marine Outfall

General Comments

This report provides baseline information on contaminants for one of the most sensitive indicators of the outfall, geoduck tissues. In general, the chemical methodology, organismal handling, and quality assurance are carefully done and clearly reported. Suitable detection limits for ensuring compliance with human health guidelines needs to be carefully considered. Sampling of mussels in a pristine California embayment (Tomales Bay) yields PCB concentrations in the 1-10 ng/g range. I would anticipate similar concentrations in geoducks, but the detection limits were 13 ng/g. Is it important to accurately characterize those baseline levels?

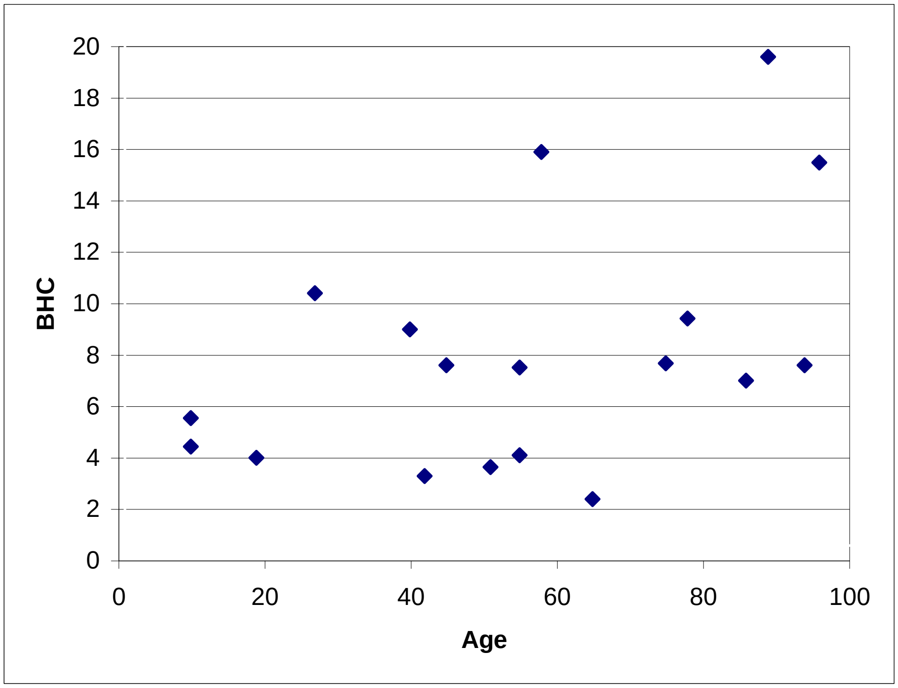
Specific Comments

Sec. 2.2 p 5 -

Given the observance of some contamination associated with more sample handling in the results, it would be wise to re-evaluate the sampling methodology for future sampling. Can you make any recommendations here?

Sec 4.4.1 p.13

I've plotted BHC concentrations versus age below.



There is a hint of a correlation. In future monitoring, it may be worthwhile to develop a target size range for clams picked for analysis.

App. C p.3

When the spike recovery fails the lower control limit—here recoveries were 46% and 40%--the non-detects should be flagged so that the reader is aware of the potential of a false negative.

Summary

This report provides a good baseline. Because of the evidence of the relationship between size and tissue concentration for at least mercury, I would recommend future studies constrain the size of animals collected. In addition, I would recommend that King County evaluate using the “new” EPA method 1668 for the PCB congeners. Most monitoring plans have already made the switch in order to better characterize the reduced concentrations now found in the environment.

END OF CONNOR FULL TEXT REVIEW

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

Respondent: Scott Mickelson, King County DNR

Mike Mickelson

General questions:

1. The herbicide analyses failed. Have others measured it successfully? Why do you think this is worth measuring? (I wouldn't know)

> *RESPONSE: I'm not aware of other studies have measured chlorinated herbicides in geoducks (not a lot of studies, period.) We chose to attempt to measure these compounds in geoducks because many of them are still in use in King County and have been detected in surface water (2,4-D is detected frequently).*

2. Four of the nine stations do NOT have unique coordinates (Table A-1; Fig 1) even though they have different depths. Is this a typo or a steep cliff face?

> *RESPONSE: Steep cliff face coupled with the resolution of the hand-held GPS equipment.*

3. Error? The Pb-lead data for GDK7S-1W seem low for whole tissue and for GDK7S-2E seem high for edible tissue.

> *RESPONSE: No error. These were the data as reported by the analytical laboratory.*

4. Many of the results for organics were below the detection limit. The study should not be repeated without reconsidering the choice of analytical methods. Given the industrial past of Point Wells, would you expect to detect oil contamination with more sensitive methods? If so, that might be important baseline information.

> *RESPONSE: In general, measurement of total petroleum hydrocarbons is on a gross scale. If the need arises, would want to investigate lowering detection limits on some of the constituents of petroleum products, most likely PAHs. It's possible that we could look at doing some "forensic" petroleum chemistry, although I'm not aware if this has been done in a tissue matrix before. It's quite expensive so the cost would have to be justifiable.*

5. What does Musselwatch say about Puget Sound? Wasn't there a lot of oil pollution?

> *RESPONSE: The Mussel Watch program doesn't have a sampling station in the north Puget Sound area and many of their sampling stations are intertidal rather than subtidal.*

Mike Connor

Respondent: Scott Mickelson, King County DNR

General questions pertaining to detection limits:

"Suitable detection limits for ensuring compliance with human health guidelines needs to be carefully considered. Sampling of mussels in a pristine California embayment (Tomales Bay) yields PCB concentrations in the 1-10 ng/g range. I would anticipate similar concentrations in geoducks, but the detection limits were 13 ng/g."

1. Is it important to accurately characterize those baseline levels?

> *RESPONSE: The schedule and budget for the geoduck tissue study was such that we needed to use our own laboratory for PCB analysis and did not have time to establish a contract with an outside laboratory. If PCBs (or other organics) in geoducks becomes a driving issue, it is likely that we would establish a contract with a specialty laboratory such as Axys Analytical that would be able to perform ultra-trace level work. Our laboratory is also always investigating ways to decrease detection limits for special projects while still operating in their mandated capacity as a non-research, production-level, wastewater-operating laboratory.*

From the full text review- referring to Section 2.2 (page 5):

1. "Given the observance of some contamination associated with more sample handling in the results, it would be wise to re-evaluate the sampling methodology for future sampling." *Agree*. "Can you make any recommendations here?"

> *RESPONSE: The geoduck tissue study was somewhat of a "last minute" addition to the geoduck population study and sampling was driven by the schedule and the necessity to document the springtime "show factor" survey. Since geoducks are collected by divers, planning for future studies, if they occur, would include evaluation of alternatives to typical neoprene diver's gloves and plastic mesh bags for storage. We were caught off guard by the size of some of the geoducks and the inability to fit into our glass sample containers. This resulted in storage in plastic food storage bags and the resulting phthalate contamination. A further evaluation of protective gloves for use during dissection is also warranted.*

Document 5: *Existing Water Quality Conditions Study, Offshore Water Column and Intertidal Environments of the Central Puget Sound Basin, Sampling and Analysis Plan. June 2001*

Coordinator's Summary

Both peer reviewers examined the entire technical document, and provided comments independently. The reviewers agreed the Sampling and Analysis Plan provided some clarity about project objectives, but also revealed some insensitive methods (i.e., mercury, various nutrient analyses).

Michael Connor: Ecology comments

The report was organized, well written, and "demonstrate[d] clearly some of the thinking behind the program." The reviewer was concerned about design integration with other MOSS components, "the extent to which the rationale would change based on other findings," and data comparability with current oceanographic studies at the University of Washington (UW). He was pleased that the program lab had developed more sensitive methods for mercury, and hoped that they would use the experience to upgrade their nutrient methodologies to the data quality objectives used at the UW laboratory. The reviewer suggested such sensitive methods "might be a worthwhile evaluation process for some of the lipophilic organics." Finally, as an "important integrator" of related water quality reports, this document should be "re-visited as it becomes clear what other issues emerge."

Recommendations: 1) Regarding laboratory methodologies, "…use the same methods that the University of Washington is using to promote data comparability, or, at a minimum, conduct an interlab comparison," and 2) "determine which contaminants are of concern to the regulatory agency in sensitive species…and then evaluate the sensitivity necessary in the water column to eliminate the outfall as a possible contributor."

Michael Mickelson: Chemistry comments

The reviewer commented that "one aspect of the goals became clearer" when detection of a 50% change from the mean was stated in the metals section of the Data Quality Objectives discussion. Subsequent discussion of statistics seemed "awkward and uneven," however, with "contortions for nondetects" that may have been measured unnecessarily.

Sampling stations proximate to existing outfalls will be most useful in predicting "what to expect from a new outfall," therefore additional stations should be positioned near one of the existing outfalls. The reviewer acknowledged that the station configuration "is optimized not to map spatial patterns but simply to compare before and after." It was suggested that when revisiting stations "it may be more useful to specify realistic operational bounds and to balance spatial accuracy with the need for synopticity."

Finally, the reviewer questioned the insensitive method detection limits for some of the nutrient analyses, and commented that "NH4 and PO4 are useful tracers of an outfall plume were you to try and map the outfall plume."

Document 5: *Existing Water Quality Conditions Study, Offshore Water Column and Intertidal Environments of the Central Puget Sound Basin, Sampling and Analysis Plan. June 2001*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Puget Sound Peer Review

Reviewer: Michael Connor

Document	Existing Water Quality Conditions Study, Offshore Water Column and Intertidal Environments of the Central Puget Sound Basin, Sampling and Analysis Plan
General Comments	This section does a nice job of summarizing the overall water quality conditions study. The text is clear and well-written and demonstrates clearly some of the thinking behind the program (see Table 1 and Table 2). I worried about how well this design was integrated with other issues in the study, the extent to which the rationale would change based on other findings, and how well the data fitted with the oceanographic studies conducted at the University of Washington (UW). For instance, the water quality measurements use standard methods rather than the oceanographic methods that I presume UW used. In addition, the lab is now using more sensitive methods for mercury. I would presume that might be a worthwhile evaluation process for some of the lipophilic organics. The obvious process would be to determine which contaminants are of concern to the regulatory agency in sensitive species—dioxins and PCBs—are two obvious candidates and then evaluate the sensitivity necessary in the water column to eliminate the outfall as a possible contributor.
Specific Comments **Sec. 4.1.1, p.7**	Station positioning will not be as important as tidal information in collecting the water column data. Are you re-visiting the stations at the same tidal height?
Sec. 4.1.1, p.7	I recommend that you use the same methods that the University of Washington is using to promote data comparability, or, at a minimum, conduct an interlab calibration.

Summary

This report is an important integrator of the other water quality reports. It will need to be re-visited as it becomes clear what other issues emerge.

References

If the UW references are not available, MWRA has a good QA/QC report for water column sampling found at: http://www.mwra.state.ma.us/harbor/enquad/pdf/ms-074.pd which is cited as Libby PS, Gagnon C, Albro CS, Mickelson MJ, Keller AA, Borkman D, Turner JT and Oviatt CA. 2002. Combined work/quality assurance plan (CWQAPP) for water column monitoring 2002 - 2005 - tasks 9, 10, 12, 13, 14, 15. Boston: Massachusetts Water Resources Authority. Report ms-074. 79 p.

END OF CONNOR FULL TEXT REVIEW

Reviewer: Michael Mickelson

Document Reviewed:
Existing Water Quality Conditions Study, Offshore Water Column and Intertidal Environments of the Central Puget Sound Basin, Sampling and Analysis Plan.

General Comments

The stations near existing outfalls will be most informative for what to expect from a new outfall. There should be more stations near one of the existing outfalls – or is that covered in other monitoring studies?

What outfall effects can you detect now? Can you see any patterns?

Specific Comments

<u>Section 3.1, Data Quality Objectives - Metals</u>
Page 2: One aspect of the goals became clearer when you stated that [it is important that you decided] you want to be able to detect a 50% change from the present mean, with the stated power and significance. Can you explain where the 50% came from? If you have information on variability then you can of course calculate the number of samples required. The remainder of the discussion of statistics seems awkward and uneven, with contortions for nondetects that you probably shouldn't even have bothered to measure.

Section 4.3.1, Precision, Accuracy, and Bias
Page 3: This page describes the importance of field replicates, and later sections of the report do a thorough job of specifying how many field replicates to collect.

Page 4: "The goal for completeness is 100 %."

Page 7: "the station must be revisited as precisely as possible." Suggestion: it may be more useful to specify realistic operational bounds and to balance spatial accuracy with the need for synopticity. FYI Libby et al. (2001) says: "It is expected that 100% of the samples collected and intended for analysis will be analyzed. However, a sample loss of <10% for the entire project will not compromise the objectives of the project." He also says "sampling will be conducted within 300 m of the targets as visualized on the … navigation display."

Page 4: Some stations coincide with "long-term monitoring stations". Can you mention the years past and planned of that study and provide a citation?

Page 5: The transect surveys of Fig 3 will take a while to complete, and currents will change. Will you know the currents and correct for them somehow in the data analysis?

Page 12: PO4 is not measured in the MOSS program. NH4 and PO4 are useful tracers of an outfall plume were you to try to map the outfall plume.

Page 12: Insensitive methods. The method detection limits for some of the nutrient analyses are about 100 times the standard oceanographic methods used in the HOM program (Libby et al 2001). Is this an error?

Analysis	MOSS_MDL	HOM_MDL	units
NH4	0.01	0.00028	mg/L as N
NO3	0.02	0.00014	mg/L as N
NO2	0.02	0.00014	mg/L as N
PO4	?	0.00031	mg/L as P
SiO4	0.05	0.00056	mg/L as Si

Section 5.1.1

Page 12: "Nitrate alone may be determined…" "may"is confusing, especially because you don't do this.

Page 13: The handheld and shipboard turbidity sensors have different responses. How will you relate them?

You plan to measure metals and organics contaminants in water samples. Isn't it even harder to detect these in water than in sediments and fish/shellfish?

Summary

The station layout is optimized not to map spatial patterns but to simply compare before and after. That may suffice. It may not be necessary to map the extent of impact of existing outfalls, and it may be beyond King County's responsibility to determine the assimilative capacity of Puget Sound.

References

Libby PS, Hunt CD, McLeod LA, Geyer WR, Keller AA, Oviatt CA, Borkman D, Turner JT. 2001. 2000 Annual Water Column Monitoring Report. Boston: Massachusetts Water Resources Authority. Report ENQUAD 2001-17. 196 p.

END OF MICKELSON FULL TEXT REVIEW

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

--NOT PROVIDED FOR THIS TECHNICAL DOCUMENT--

Michael Connor

From the full text review, Section 4.1.1:

3. Station positioning will not be as important as tidal information in collecting the water column data. Are you re-visiting the stations at the same tidal height?

Michael Mickelson

From the full text review, General Comments section:

D. Is the issue of additional stations near existing outfalls covered in other monitoring studies?
E. What outfall effects can you detect now?
F. Can you see any patterns?

From the full text review, Section 3.1:

G. Regarding detecting a 50% change from the mean (metals constituent in the DQO's): Can you explain where the 50% came from?

From the full text review, Section 4.3.1:

H. Some stations coincide with "long-term monitoring stations". Can you mention the years past and planned of that study and provide a citation?
I. The transect surveys of Fig 3 will take a while to complete, and currents will change. Will you know the currents and correct for them somehow in the data analysis?
J. The method detection limits for some of the nutrient analyses are about 100 times the standard oceanographic methods used in the HOM program (Libby et al 2001). Is this an error?

From the full text review, Section 5.1.1:

K. The handheld and shipboard turbidity sensors have different responses. How will you relate them?

You plan to measure metals and organics contaminants in water samples. Isn't it even harder to detect these in water than in sediments and fish/shellfish?

Document 6: *Seasonal patterns and controlling factors of primary production in Puget Sound's Central Basin and Possession Sound Technical Memorandum. September 2001*; and

Document 7: *Seasonal patterns and controlling factors of primary production in Puget Sound's Central Basin and Possession Sound: assessing the role of nutrient limitation. November 2002*

Coordinator's Summary

Both documents described Primary Productivity and nutrient limitation at four stations in Puget Sound over a three-year period. The reviewers agreed that extended incubation time in bottles can affect nutrient limitation, the surface dissolved inorganic nitrogen (DIN) appeared to be limiting, though not as much as was reported, and the role of zooplankton grazers could be important.

Michael Mickelson: Chemistry comments

The technical documents were reviewed together and presented as one set of comments. They are summarized together below.

The reviewer provided a graphical illustration of the author's data where "spiked nutrients enhance[d] productivity only when nutrients [were] low [in summer]" for incubated water samples from Puget Sound. Surface waters "could have a eutrophic response to nutrients discharged from an outfall" during summer, but would be unlikely since the "outfall plume will by design be trapped below the pycnocline" during that period. "The implications for outfall effects from this study are very conservative."

It would be useful to show data at surface depths in addition to depth-integrated data since "integration masks what may be a more dramatic stimulation in the surface samples." Also, it would be valuable to specify the "measurements of nutrients after incubation" to denote changes during incubation.

The method used for measuring responses to nutrient addition in incubated bottles was acceptable and "appealing in its operational simplicity." However, extended incubation periods can "allows [a] sample to change" because nutrients are depleted, "so growth simply stops before the end of the incubation."

Lastly, the reviewer suggested, "zooplankton grazers may have a very important role."

Recommendations: 1) "Measure Particulate Organic Carbon to have a handle on the whole community. Particulate Nitrogen is also important."

<u>Aimee Keller</u>: Biology comments

The technical documents were reviewed separately and presented as two sets of comments. They are summarized independently below.

Summary for the *Seasonal patterns and controlling factors of primary production in Puget Sound's Central Basin and Possession Sound Technical Memorandum*:

The reviewer emphasized the importance of primary productivity research "prior to siting a marine outfall." Since the data appear to be lacking in Puget Sound "for determining historical baseline productivity," those presented in this document are "particularly important."

The document should contain a "detailed summary of the methods" because some components were unclear (e.g., nutrients and chlorophyll measurements at each depth). Hence, the reviewer consulted with the report author's for clarification of the methods. The "nutrient addition experiments" were incompletely described. Also, the experimental design should include a new section for describing the method for selecting stations and the reason the "observed measurement frequency was chosen." Finally, "the experimental design for the nutrient addition experiments need[ed] to be included in the report."

The "annual productivity cycles" and relevant relationships were clearly presented in Figure 2. "The daily rates should [have] been integrated over time to calculate annual productivity rather than averaged because of the unequal periods between measurements." Factors controlling "seasonal and interannual differences observed in primary productivity in the Sound" should be analyzed further. For example, temperature and salinity "should be used to determine density and the mixed-layer depth." Lastly, the results of the measured phytoplankton species composition were not available in the discussion. Variation in productivity between stations and years "may be tied to difference in phytoplankton species composition and abundance."

Next, the reviewer commented on the incubation procedure. Nutrient limitation occurred due to "long incubation times and high biomass," and measurements before and after incubations "confirm[ed] that nutrient concentrations in ambient bottles decreased over the incubation period." If decreased below the measured Puget Sound levels then "most likely the measured increase in the spiked bottles is inflated relative to what would have happened in situ." The "decrease in nutrients in ambient and increase in productivity in spiked bottles" occurred, in some cases, when nutrients were at low levels. The reviewer said these results "support[ed] the findings" that additional nutrients via outfalls could increase productivity and potentially decrease water quality. Thus, "care should be taken to determine during which periods of the year and over what areas of the Sound such changes are likely to occur."

The reviewer showed in Table 1 that nutrient addition data suggested, "limitation is occurring somewhat less frequently…than indicated by experimental results." It was noted that a "relatively high variability [was] associated with the technique" based on the decreased productivity in spiked bottles. Thus, "it was difficult to explain why production would decrease with added nutrients." Surface DIN concentrations "appear[ed] to be limiting on occasion but less frequently than suggested by the nutrient addition experiments." Productivity was greater for spiked versus ambient bottles despite high nutrient concentrations at the outset of incubation in the ambient bottles. A second Table provided by the reviewer indicated "large increases in productivity…are associated with relatively small increases in the measured rate."

As communicated to the reviewer by one report author, "replicate productivity measurements were made for each treatment;" thus, the differences should be examined "to determine when the increase in productivity in spiked samples is [statistically] significant." It was suggested that routine measurements of productivity "near and downstream of the outfall" would be useful and "provide rate measurements for use by modelers." Also, "depth-specific data" should be presented in the appendices. Lastly, an increased number of "productivity measurements included in the long-term monitoring plan so that a strong baseline exists against which to compare future changes."

Recommendations: 1) Add a row to Table 3 in the document to show "the number of times nutrient limitation could be occurring in the Sound based on in situ DIN concentration."

Summary for the *Seasonal patterns and controlling factors of primary production in Puget Sound's Central Basin and Possession Sound*: *assessing the role of nutrient limitation*:

The document included data for an additional ten months of study, and the "variables measured, methods, experimental design, results, analyses and conclusion were well written and carefully approached." The methods included the nutrient concentrations added to the spiked bottles, and the calculations for "average annual productivity" allowed for "variation in sampling frequency (i.e., trapezoidal integration)."

"Spatial variability in production appear[ed] related to…the depth of mixed layer and the extent of stratification." Therefore, "since nutrient limitation is related to stratification," the study suggested placement of the outfall should not correspond with an "area subjected to year-round stratification."

The reviewer provided Table 1 comparing productivity at the four stations in Puget Sound with "published values from a number of estuaries." The importance of the current research was apparent and the reviewer "urge[d] the authors to consider publication."

A second Table provided by the reviewer compared surface DIN concentrations from this study with the 2001 King County water quality monitoring report. Some discrepancies were evident, reasons unknown to the reviewer. Nutrient limitation "may be occurring in situ" for concentrations recorded during the King County study.

Results from this study support findings in the phase 2 report that "care should be taken in siting the outfall to avoid areas with well-developed year-round or seasonal stratification." Also, "archived phytoplankton samples" should be analyzed further, and the "role of grazers" explored. Finally, the reviewer "strongly urge[d]" completion of the model described in the document.

Document 6: *Seasonal patterns and controlling factors of primary production in Puget Sound's Central Basin and Possession Sound Technical Memorandum. September 2001*; and

Document 7: *Seasonal patterns and controlling factors of primary production in Puget Sound's Central Basin and Possession Sound: assessing the role of nutrient limitation. November 2002*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

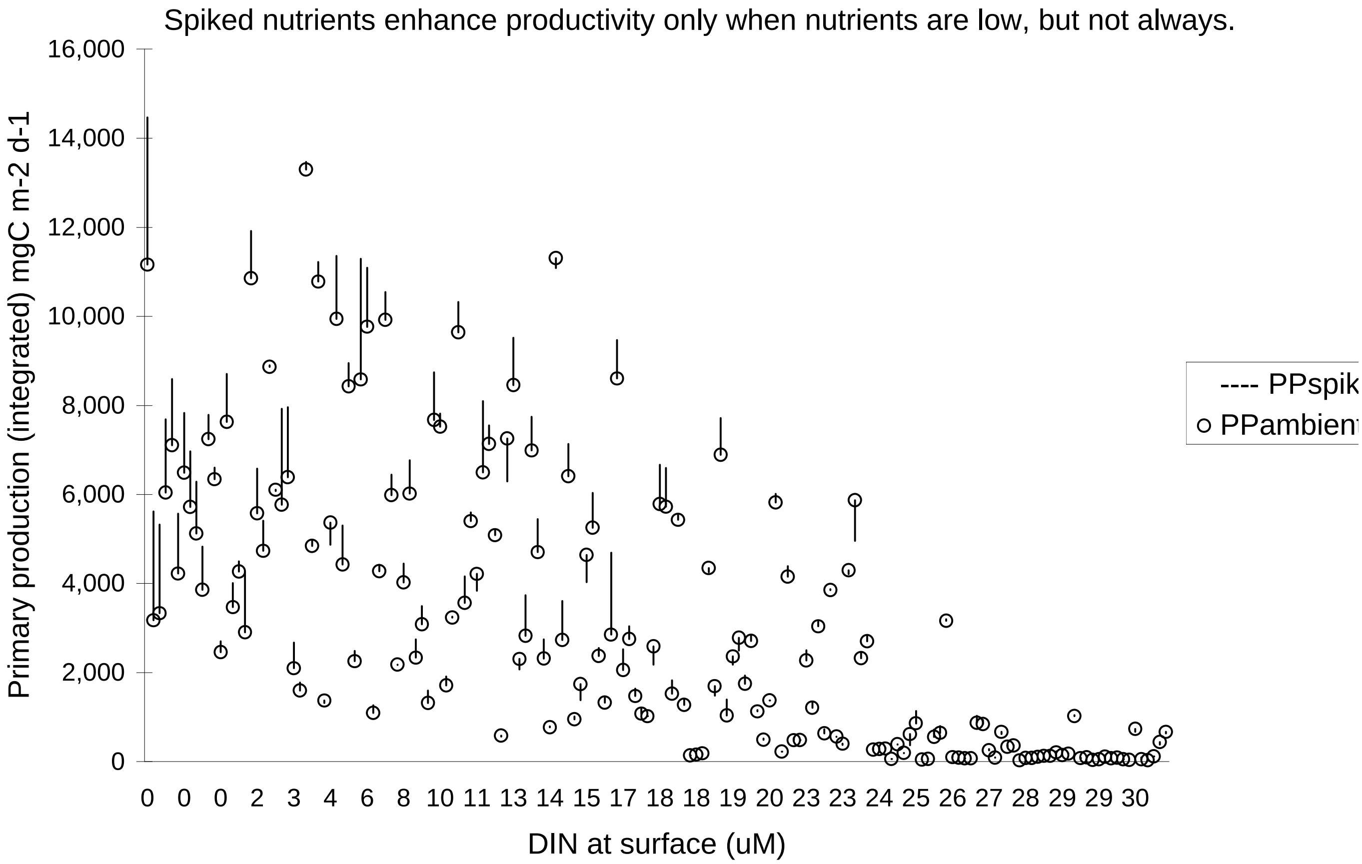
Reviewer: Michael Mickelson

Documents Reviewed:

1. Seasonal patterns and controlling factors of primary production in Puget Sound's Central Basin and Possession Sound Technical Memorandum
2. Seasonal patterns and controlling factors of primary production in Puget Sound's Central Basin and Possession Sound: assessing the role of nutrient limitation

General Comments

Nakata et al (2001) evaluate the potential for eutrophication at four sites in Puget Sound by adding nutrients to water samples from the sites, incubating them under simulated natural conditions, and measuring the response. (Only samples in the euphotic zone, avg = 20m depth, were tested because deeper samples would obviously be light limited.) The added nutrients stimulated the growth in some of the samples. These were in April-September for which surface nitrate was less than half the winter levels (see Figure).



Those nutrient-limited samples represent surface waters that could have a eutrophic response to nutrients discharged from an outfall, if the outfall plume were to reach them during summer. But this is not likely to happen because the outfall plume will by design be trapped below the pycnocline in summer. Thus the implications for outfall effects from this study are very conservative. An extra measure of safety is that the favored outfall site is at Point Wells rather than Posession Sound which is more complex and susceptible to nutrients.

Specific Comments

The reported productivity values seem high compared to the theoretical maximum rates (e.g. Libby et al. 2001, see page 5-7). Could the author examine this issue?

The report is brief and mostly shows only depth-integrated data. That is good for management purposes, but it would be interesting to see the data at each depth, particularly at the surface. For example, the author speaks of “substantial” production increases in response to added nutrients, but the increase was small, only about 40% in the integrated data. Integration masks what may be a more dramatic stimulation in the surface samples.

The report alludes to but does not show the measurements of nutrients after incubation. The data are valuable. They may show how much the nutrients change during incubation. If they are entirely used up then growth would stop, but continue in a spiked sample.

The author interprets the measured nutrient-stimulated response as evidence of an increase in the RATE of primary production in the incubated test bottles. One could debate whether the nutrient addition increases growth rate or growth yield. For outfall management the distinction may not matter. The method used has acceptance in that it is similar to that recommended by USEPA (2001), and it is appealing in its operational simplicity. But every incubation method has its own peculiar problems and for this method the issue is that the long duration of the incubation allows sample to change; nutrients are used up and depleted, so growth simply stops before the end of the incubation. The nutrient spike then merely extends the time of growth and does not increase the rate. This may seem like semantics but is typical of concerns in the literature about productivity measurements (Platt et al. 1989). There is a good discussion of the merit of the present approach in Newton et al. (2001).

What does the method tell us that we can't infer from nutrient concentrations? Newton et al. (2001) develop this concept thoroughly.

The author interpreted some of the interannual patterns in terms of inferred upwelling and even ENSO events farther offshore in the Strait of Juan de Fuca. Offshore influences are certainly important – is monitoring there adequate? Newton et al. (2001) recommend expanded monitoring there (not by King County).

Puget Sound would be very eutrophic except to light limitation, energetic flushing (in parts), and settling out of nutrients – the zooplankton grazers may have a very important role. Recommendation: Measure Particulate Organic Carbon to have a handle on the whole community. Particulate Nitrogen is also important.

Summary

Surface waters at Point Wells are occasionally nutrient-limited in summer (but the outfall would not reach the surface then anyway).

References

1. Libby PS, Hunt CD, McLeod LA, Geyer WR, Keller AA, Oviatt CA, Borkman D, Turner JT. 2001.

2. 2000 Annual Water Column Monitoring Report. Boston: Massachusetts Water Resources Authority. Report ENQUAD 2001-17. 196 p.

3. Nakata K, Newton J, Parametrix. 2001. Seasonal Patterns and Controlling Factors of Primary Production in Puget Sound's Central Basin and Possession Sound.

4. Newton JA, S.L. Albertson SL, Van Voorhis K, Maloy C, Siegel E. 2001. Washington State

Marine Water Quality 1998 through 2000. Washington State Department of Ecology, Environmental Assessment Program, Publication # 02-03-056, Olympia, WA.

5. Platt, T., W. G. Harrison, M. R. Lewis, W. K W. Li, S. Sathyendranath, R. E. Smith, and A. F.Vezina. 1989. Biological production of the oceans: the case for a consensus. Mar. Ecol. Prog. Ser. 52: 77-88.

6. U.S. EPA 2001. Nutrient Criteria Technical Guidance Manual: Estuarine and Coastal Marine Waters. Chapter 4, Field and Laboratory Methods.

END OF MICKELSON FULL TEXT REVIEW

Review Date: February 21, 2003

Reviewer Name: **Aimee A. Keller**

Technical Document being reviewed: **Seasonal patterns and controlling factors of primary production in Puget Sound's central basin and Possession Sound**

General Comments:
I believe this is a particularly important component of the research being conducted prior to siting a marine outfall in Puget Sound. Primary productivity is a fundamental ecosystem characteristic with the level of productivity setting the upper bound on all processes within the system up to and including fish production. Very little data appear to be available for determining historical baseline productivity in the Sound. Thus the data included in the report are particularly important. The report describes productivity measurements made at 4 stations over a 2-year period in central Puget Sound. Standard C-14 techniques were used to measure primary productivity. Ancillary data on nutrient concentrations, chlorophyll, PAR, phytoplankton species, temperature, salinity and secchi depth were also collected. Extinction coefficients were calculated based on secchi disk depth as k=1.6/secchi depth (m). More precise estimates of light attenuation may be made with an underwater light meter rather than a secchi disk.

A detailed summary of the methods should be included in the report. It was not initially clear to me if nutrients and chlorophyll were measured at each depth. Fortunately, my questions regarding methods were answered promptly by the authors of the report. Perhaps the link to the methods paper should be cited within the report. In particular, insufficient detail is given in the report about the nutrient addition experiments. What concentration of nutrient was added, did it vary over time, were nutrient concentrations in the incubation vials measured before and after the incubations? The results in Table 3 imply that such measurements were made but it was not noted in the methods.

The methods indicate that incubations were run with the lowest light level set at the 1% level to incorporate the entire euphotic zone. The data I examined for 4 Aug. 1999 (J. Newton, personal communication) indicate that the lowest light level used during incubation was 1.6%. I was not sure if samples were also collected at the depth corresponding to the 1.6% level or the 1% level. I calculated an extinction coefficient using the secchi disk depth (4.2 m) given for Point Wells on 4 Aug. 1999 as k=1.6/4.2, with k=0.381 m^{-1}. The depth of the 1% level is then calculated as: $\ln(1\%) = e^{-0.381z}$; solving for z yields a depth of 12.1 m. When this process is repeated using the 1.6% light level, solving for z yields 10.8 m. In appendix 1b, the euphotic depth on 4 Aug. 1999 is given as 10.8 m. This is a minor discrepancy but the methods should reflect the actual light levels used in collecting and incubating samples.

A section should be added on experimental design to fully explain how the stations included in the study were selected and why the observed measurement frequency was chosen. The abstract implies that the data were primarily collected as input for a modeling effort. If developing the model was the basis of site selection and measurement frequency this should be explained. The experimental design for the nutrient addition experiments needs to be included in the report.

Results – The annual productivity cycles and relationships between productivity, phytoplankton biomass, and nutrient concentrations are clearly presented (Figure 2). However, the data for Admiralty Inlet are difficult to see and an alternate color needs to be chosen for the graphs. Over much of the year, the variation among stations is low which is perhaps as interesting as the periods when the stations vary.

The daily rates should be integrated over time to calculate annual productivity rather than averaged because of the unequal periods between measurements.

I would like to see the P-I curves included in the results. Did photoinhibition occur?

Additional analyses are needed to determine the factors controlling both the seasonal and interannual differences observed in primary productivity in the Sound. Data were collected on temperature and salinity and should be used to determine density and the mixed-layer depth. Such an approach would add substance to the hypothesized interaction between production and stratification.

Although the methods indicate that phytoplankton species composition was measured, no mention of these results is included in the discussion. Some of the variation in productivity between stations and years may be tied to difference in phytoplankton species composition and abundance. With additional years of data, the controlling factors may be easier to discern.

The relative increase in productivity in the nutrient-spiked incubation bottles may, on occasion, be a result of nutrient limitation in the ambient incubation bottles. Nutrient limitation occurs with long incubation times and high biomass, both of which were present in this study. Nutrient concentrations in the incubation bottles were measured before and after the C-14 incubations and confirm that nutrient concentrations in ambient bottles decreased over the incubation period. If nutrient concentrations in the ambient bottle decreased below levels measured in the Sound then most likely the measured increase in the spiked bottles is inflated relative to what would have happened in situ. In some cases the decrease in nutrients in ambient bottles and increase in productivity in spiked bottles occurred during periods when nutrients were at low levels in the Sound. These results support the findings that adding nutrients via an additional wastewater treatment plant may lead to increased productivity and perhaps decreased water quality. Care should be taken to determine during which periods of the year and over what areas of the Sound such changes are likely to occur. I think a row should be added to Table 3 in the report showing the number of times nutrient limitation could be occurring in the Sound based on in situ DIN concentration. Using a conservative estimate for limitation of <5 μM DIN (surface, in situ) suggests that limitation is occurring somewhat less frequently at all stations than indicated by experimental results (Table 1). However, the observed incidence of limitation is Possession Sound remains elevated relative to the other stations measured, as noted by Nakata and Newton (2001).

Table 1. Increase in production due to nutrient addition. Number of times threshold was surpassed at each station, out of 32 sampling dates. (Rows 1-3 from report; row 4 added here).

Criteria	Admiralty Inlet	Possession Sound	Point Wells	West Point
Increased P (>450 mg C m^{-2} d^{-1})	6	9	6	8
Increased P (>15%)	7	11	8	8
Increased Nut Utilization	6	12	7	8
In situ DIN (<5µM)	3	10	5	5

I believe that there is a relatively high variability associated with the technique based on the decreased productivity observed in nutrient- spiked bottles (up to 33%). Decreased production in nutrient spiked bottles occurred about 20% of the time. Percent decrease in productivity with added nutrients may be a surrogate value for measurement variability, since it is difficult to explain why production would decrease with added nutrients. Surface DIN concentrations appear to be limiting on occasion but less frequently than suggested by the nutrient addition experiments. I am puzzled by the measured increases in productivity (>20%) in spiked versus ambient bottles, when nutrient concentrations were high (>15 µM) at the start of the incubation in the ambient bottles (Table 2). Table 2 indicates that some of the large increases in productivity (measured as percent increase) are associated with relatively small increases in the measured rate (ex. the 76% increase seen in Dec. 1999 at Point Wells). Perhaps these bottles also provide a measure of the variability inherent in the technique.

Table 2. Results with high surface DIN (mM) and large increases in productivity in spiked versus ambient samples.

Date	DIN(µM) surface	Delta P (mg C m^{-2} d^{-1})	% change
Admiralty Inlet			
25 Aug. 1999	15	878	32
7 Dec. 1999	30	22	29
13 Nov. 2000	25	273	32
Point Wells			
17 Mar. 1999	27	164	19
15 Sep. 1999	17	1840	64
7 Dec. 1999	31	41	73
Possession Sound			
10 Feb. 1999	29	35	27
17 Mar. 1999	26	165	30
West Point			
10 Feb. 1999	30	19	20
6 Oct.1999	19	353	34

10 Jan. 2000	31	14	41

The data that I received from Jan Newton indicates that replicate productivity measurements were made for each treatment (ambient versus spiked). The differences between treatments should thus be statistically evaluated to determine when the increase in productivity in spiked samples is significant.

The data appendices should include the depth-specific data.

Additional thought should be given to measuring productivity on a routine basis at a subset of stations. Before and after measurements near and downstream of the outfall would assist managers in addressing the impacts of the outfall on the system and provide rate measurements for use by modelers.

The data collected during the productivity study suggest different responses to nutrient additions in different regions of the Sound. This information is of use in siting the outfall and should be carefully considered.

Specific comments
Abstract – final sentence. Are modeling and assessment of the productivity measurements underway?
Introduction – 1st sentence. The existing 20 years of data collected on nutrient concentrations in Puget Sound should give some indication of the long-term changes presumed to be occurring and yet these data do not appear to be readily available.

Methods – I was surprised by the use of the secchi disk to estimate extinction coefficients; underwater light meters are relatively inexpensive and should provide improved estimates of k (m^{-1}).

Paragraph 2 line 1. The date for the Strickland and Parsons reference is incomplete. Plus the reference is not included in the literature cited section.

The nutrient concentration used to spike the experimental bottles should be included in the methods, along with an explanation for the selected concentration. Were nutrients added in sewage derived ratios?

I would prefer to see the depth specific data included in the appendices as well as the integrated values.

Phytoplankton production is an important measurement to make when assessing the impact of wastewater delivery to an estuarine system. I would like to see additional productivity measurements included in the long-term monitoring plan so that a strong baseline exists against which to compare future changes.

Review Date: February 22, 2003

Reviewer Name: **Aimee A. Keller**

Technical Document being reviewed: **Seasonal patterns and controlling factors of primary production in Puget Sound's central basin and Possession Sound: Phase 3**

General Comments

This report is an extension of the phase 2 productivity report and includes an additional ten months (Jan. – Oct. 2001) of data at the four productivity stations. The methods section is improved and includes the concentration of nutrients added to the spiked incubation bottles. Indices of average annual productivity were calculated by trapezoidal integration, which accommodates the variation in sampling frequency, rather than as arithmetic means, as was implied in the earlier report.

Spatial variability in production appears related to physical processes, primarily the depth of the mixed layer and the extent of stratification. Water column stratification was shown to vary by region and explained a portion of the variability in production between sites. Possession Sound is well stratified year-round throughout much of the study. During drought periods (winter 2001), stratification breaks down and productivity more closely approximates values seen in other areas. Since nutrient limitation is related to stratification, the degree of stratification is an important feature to consider in the outfall siting process. The results of the productivity study suggest that the outfall should not be placed in an area subjected to year-round stratification.

With three years of data distinct seasonal productivity patterns have emerged. Productivity was high and variable from March – September and low and less variable from October – February. A spring bloom occurred each year at all stations followed by a decline in production. Summer and fall blooms occurred but the timing and extent varied among stations.

Annual productivity at the four stations in Puget Sound was very high. I compared productivity at these stations with published values from a number of estuaries (Table 1). The current productivity values for Puget Sound are greater than the value for Puget Sound previously included by Nixon et al. (1986) in their review. Unfortunately, the citation for this value was not included in Nixon et al.'s (1986) manuscript and the location within the Sound was not specified. The lower values observed for annual productivity in Puget Sound are within the range reported for several other systems, while the upper value is greater than values reported in other areas. These comparisons emphasize the importance of the current research and I urge the authors to consider publication.

Table 1. Estimates of annual primary production (g C m^{-2} y^{-1}) in various estuarine ecosystems (from Nixon et al. 1986 and references therein).

Estuarine Systems	**g C m^{-2} y^{-1}**
Bedford Basin, Nova Scotia	220
St. Margaret's Bay, Nova Scotia	790
Narragansett Bay, Rhode Island	310
Peconic Bay, Ling Island, New York	190
Lower Hudson Estuary, New York	690-925
Mid-Chesapeake Bay, Maryland	335-780
Pamlico River Estuary, North Carolina	200-500
Inshore Sounds, North Carolina	345
North Inlet, South Carolina	260
Inshore Sounds, Georgia	300
Apalachicola Bay, Florida	360
Barataria Bay, LA	360
Kaneohe Bay, Hawaii	165
Boston Harbor MA	263-787
Massachusetts Bay, MA	170-679
Puget Sound, WA (in Nixon et al. 1986)	465
Puget Sound, WA (this study)	694-1351

I compared surface DIN in appendix 1a for Admiralty Inlet from Jan. – Jun. 2001 and appendix 1b for Point Wells from Jan. – Oct. 2001 with surface DIN from the water quality monitoring reports (King County) – although the values generally were in close agreement (Table 2), some discrepancies are apparent. I was unsure why these differences occurred.

Table 2. Comparison of surface DIN (μM) in the current study to those reported for the same stations in the water quality monitoring report (King County 2001) for Jan.– Oct. 2001. Dates varied by a few days.

Month	DIN – Admiralty Inlet (Prod study)	DIN – Admiralty Inlet (Water Qual. Study)	DIN –Point Wells (Prod study)	DIN – Point Wells (Water Qual. Study)
J	28	28	29	30
F	21	21	30	31
M	19	26	17	26
A	20	14	23	23
M	13	11	*12*	*2*
J	6		12	
J	*11*	*22*	3	4
A			16	15
S			*4*	*21*
O			23	23

I initially examined the concentration of DIN since the increased productivity (25%) observed at Point Wells in May when nutrients did not appear limiting in the surface waters puzzled me (and similar events on other occasions). The concentration recorded during the water quality monitoring survey is sufficiently low that limitation may be occurring in situ.

The results of the additional productivity measurements support the preliminary finding that care should be taken in siting the outfall to avoid areas with well-developed year-round or seasonal stratification. These areas are potentially most susceptible to increased productivity due to added nutrients in wastewater.

Archived phytoplankton samples should be analyzed for species composition and abundance. The role of grazers also needs to be evaluated, as noted by the authors.

I strongly urge that the modeling described in the report be completed. The model should focus on assessing the impact of potential increases in primary productivity on water quality and/or other trophic levels.

The variables measured, methods, experimental design, results, analyses and conclusion were well written and carefully approached. Additional information on historical levels of productivity measured in Puget Sound might prove useful in siting the outfall – most likely insufficient historical data exists. A solid baseline for productivity in the central basin needs to be developed to assess future impacts.

Specific Comments

Figure 3 should be expressed as percent of the water column that is well-mixed to emphasize the similarities between stations that were mixed from surface to bottom but had different depths. The axis should be reversed for ease of interpretation.

Figures 5 and 4 were reversed in my copy of the report.

The error bars in figure 8 need to be defined.

Literature Cited

King County. 2001. Water Quality Status Report for Marine Waters Submitted by King County Marine and Sediment Assessment Group.

Nixon, S. W., C. A. Oviatt, J. Frithsen and B. Sullivan. 1986. Nutrients and productivity of estuarine and coastal marine ecosystems. J. Limnol. Soc. Sth. Africa 12 (1/2): 43-71.

END OF KELLER FULL TEXT REVIEW

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

--NOT PROVIDED FOR THESE TECHNICAL DOCUMENTS--

Mike Mickelson

General questions (pertain to both technical documents):

1. The reported productivity values seem high compared to the theoretical maximum rates (e.g. Libby et al. 2001, see page 5-7). Could the author examine this issue?
2. What does the method tell us that we can't infer from nutrient concentrations? Newton et al. (2001) develop this concept thoroughly.
3. The author interpreted some of the interannual patterns in terms of inferred upwelling and even ENSO events farther offshore in the Strait of Juan de Fuca. Offshore influences are certainly important – is monitoring there adequate?
4. Please compare the variability in spike experiments to the variability with replicate stations, depths, and bottles. In other words, can the occasional unexpected results of spiking be explained by experimental error?
5. 14C incubation experiments usually presume to measure something corresponding to a growth rate in the waters from which samples were drawn. But if nutrients are exhausted in the bottle during an incubation, are conditions still representative of the ocean? How often do you see this? Would this change the relevance of the data to outfall impacts?

Aimee Keller

Questions from the first primary productivity report (phase 2):

General questions pertaining to methods:

"Insufficient detail is given in the report about the nutrient addition experiments."

1. What concentration of nutrient was added?
2. Did it vary over time?
3. Were nutrient concentrations in the incubation vials measured before and after the incubations?

"The nutrient concentration used to spike the experimental bottles should be included in the methods, along with an explanation for the selected concentration."

4. Were nutrients added in sewage derived ratios?

General question pertaining to results:
I would like to see the P-I curves included in the results. Did photoinhibition occur?

General question:

1. Are modeling and assessment of the productivity measurements underway?

Questions from the second primary productivity report (phase 3):

NONE

Document 8: *Brightwater Marine Outfall: Baseline Sediment Characterization Study – Sediment Chemistry and Benthic Infauna Final Report – November 2002.*

Coordinator's Summary

The document was "not particularly user-friendly," with extensive data appendices, few pages of text and summaries, and no site map. The report contained "a lot of valuable data that [were] not yet accessible to the reader." Statistical information would have been clearer "if the site data [were] summarized by sites, and then compared." Lastly, there is "no comparison to other Puget Sound data" that would support the conclusion "that these sites are indicative of typical, unpolluted…sites at their depth."

The reviewer stated "very little interpretive context" was available "in which to fit the data outside the binary comparison to sediment guidelines." Using only this comparison "to judge impacts of the future discharge", a number of the contaminants were "tantalizingly close to the sediment guidelines." The changes in the Sound benthos were "not easily captured by the standard benthic indices that the report uses." Also, "the chemistry data would be more understandable if they were put in the context of the sedimentary characteristics of the area and the bathymetry."

Document 8: *Brightwater Marine Outfall: Baseline Sediment Characterization Study – Sediment Chemistry and Benthic Infauna Final Report – November 2002.*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Puget Sound Peer Review

Reviewer: Michael Connor

Document

Baseline Sediment Characterization Study for Brightwater Marine Outfall (phase 3)

General Comments

This report is not particularly user-friendly. It reads more like an outline of a final report than the report itself. It consists of a few pages of text summary and summary tables, accompanied by extensive appendices of data. I could not find a map showing the different sites selected in this document. Why not use the map in the Sampling and Analysis Plans?

Statistical information about the sites is not clearly presented. I would have preferred to see the site data summarized by sites, and then compared. It concludes that the deepwater sites are interchangeable and different from the nearshore sites. The data are not displayed in a way that the reader can easily reach that conclusion.

There is very little interpretive context in which to fit the data outside the binary comparison to sediment guidelines. If that comparison is to be the sole way to judge impacts of the future discharge, a number of contaminants are tantalizingly close to the sediment guidelines. The interpretive context for the benthic community is even more important because of the dominance of healthy Sound communities by the clam, *Macoma carlottensis*. Nichols (in press) argues strongly that the Sound benthos is changing, based on other non-Macoma species. These changes are not easily captured by the standard benthic indices that the report uses. I would recommend that the report develop a rationale for how to compare future monitoring results to this baseline condition.

It seems that the conclusion is that these sites are indicative of typical, unpolluted Puget Sound sites at their depth.

There is no comparison to other Puget Sound data to show that to be true.

Specific Comments

Sec. 1.2- There is none.

Sec. 5.2, p.15- These diversity indices are presented as a smorgasbord, without much interpretation. Are the highest diversity values good? Are these stations basically similar? It's not clear what conclusions are being drawn.

Sec. 6.1, p.17- The chemistry data would be more understandable if they were put in the context of the sedimentary characteristics of the area and the bathymetry. Is it likely that the stormwater outfall is really affecting the sediments at station Z7? What is the fingerprinting evidence—does the PAH mix in the stormwater match that in the sediments? If that is the case, do we expect the stations near the outfall with much larger loadings to be affected?

Summary This report has a lot of valuable data that is not yet accessible to the reader.

References

Nichols, F.N. in press. Interdecadal change in the deep Puget Sound benthos. Hydrobiologia:

END OF CONNOR FULL TEXT REVIEW

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

Respondent: Scott Mickelson, King County DNR

General question:

1. I could not find a map showing the different sites selected in this document. Why not use the map in the Sampling and Analysis Plan?

> *RESPONSE: Figure 1 was inadvertently left out of the PDF version of the report. This figure will be provided to all reviewers.*

From the full text review- referring to Section 5.2 (page 15):

"These diversity indices are presented as a smorgasbord, without much interpretation."

> *RESPONSE: Section 5.2 is a "results" section, interpretation is presented in Section 6.2.*

1. Are the highest diversity values good?

> *RESPONSE: Yes.*

2. Are these stations basically similar? It's not clear what conclusions are being drawn.

> *RESPONSE: All stations with the exception of the shallow station in Zone 7S are basically similar and Zones 6, 7N, and 7SB (deep) are virtually identical. This information is presented in Section 6.2 and reiterated in Section 7.1.*

From the full text review- referring to Section 6.1 (page 17):

"The chemistry data would be more understandable if they were put in the context of the sedimentary characteristics of the area and the bathymetry."

> *RESPONSE: Agree. I'm used to presenting sediment data strictly from a regulatory standpoint, based on Washington State sediment management guidelines.*

1. Is it likely that the stormwater outfall is really affecting the sediments at station Z7?

> *RESPONSE: Although I'd like to "infer" this connection based on proximity and chemicals detected in the sediment, I can't make that conclusion without storm water chemistry data.*

2. What is the fingerprinting evidence-does the PAH mix in the stormwater match that in the sediments?

> *RESPONSE: I don't have any storm water data from the Point Wells Chevron site*

3. If that is the case, do we expect the stations near the outfall with much larger loadings to be affected?

> *RESPONSE: There will always be a chemical footprint from the outfall but monitoring of our other two major outfalls indicates that the benthic community is not being adversely impacted by operation of the outfalls. There are some elevated chemicals at West Point, which are currently being investigated but the benthic community is exceptionally rich at this site with no indication of a gradient in diversity indices with respect to proximity to the diffuser.*

Document 9: *Baseline Sediment Characterization Study, Candidate Outfall Diffuser Sites, Sampling and Analysis Plan. September 2001*

Coordinator's Summary

The sampling and analysis plan was understandable but the reviewer expressed "concerns about the integration between the Data Quality Objective and the final uses of the data." The comparability issue in Section 4.1.4 would be "best addressed by being comparable to the Puget Sound Protocols." Lastly, "depending on the results of the various ecological and human health risk assessments, it may be necessary to revisit some of the detection limits."

Document 9: *Baseline Sediment Characterization Study, Candidate Outfall Diffuser Sites, Sampling and Analysis Plan. September 2001*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Puget Sound Peer Review

Reviewer: Michael Connor

Document	Baseline Sediment Characterization Study, Candidate Outfall Diffuser Sites, Sampling and Analysis Plans
General Comments	This report reads well as do the other QA/QC reports. As with the other reports, I have concerns about the integration between the Data Quality Objectives and the final uses of the data.
Specific Comments	
Sec 4.1.3 p.2-	I would characterize completeness as meaning whether the data collected were sufficient to characterize the variability of the sediments in the region. Perhaps, this issue is covered in representativeness; nonetheless, is there sufficient information to characterize the chemical composition of the site?
Sec 4.1.4 p.3-	This section seems weak to me also. The comparability question is best addressed by being comparable to the Puget Sound Protocols.
Sec 6.4 p.6	Good discussion of sample acceptability.
Sec 6.5 p.6	Most studies use the top 2 cm to characterize surface sediments. Is 10 cm specified in the Puget Sound Protocols. Does that represent 50-100 years of sedimentation?
Sec 9 p.9	How was it decided that the detection limits were sufficient for the subsequent uses of the data?
Summary	Depending on the results of the various ecological and human health risk assessments, it may be necessary to re-visit some of the detection limits.

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

Respondent: Scott Mickelson, King County DNR

From the full text review- referring to Section 4.1.3 (page 2):

1. Is there sufficient information to characterize the chemical composition of the site?

   RESPONSE: Yes, as specified under Washington State sediment management guidelines for conducting baseline sediment characterizations.

From the full text review- referring to Section 6.5 (page 6):

"Most studies use the top 2 cm to characterize surface sediments." *Not in Washington State.*

1. Is 10 cm specified in the Puget Sound Protocols?

   RESPONSE: The Washington State Department of Ecology requires collection of sediment from the 0 to 10 cm depth stratum when performing baseline sediment characterizations at almost all sites (occasional exemptions given based upon site-specific information). The 0 to 2 cm depth stratum is usually only sampled when monitoring temporal changes such as routine NPDES sediment monitoring around active outfalls when interested in more-recent deposition.

2. Does that represent 50-100 years of sedimentation?

   RESPONSE: Don't know. The 0 to 10 cm depth stratum is required because it represents the generally-accepted biologically-active zone in Puget Sound.

From the full text review- referring to Section 9.0 (page 9):

1. How was it decided that the detection limits were sufficient for the subsequent uses of the data?

   RESPONSE: The method detection limits specified in the SAP are sufficient to meet all Sediment Quality Standards chemical criteria (the most-protective criteria) specified in the Washington State sediment management guidelines, both dry-weight and organic-carbon normalized.

APPENDIX B-6

Core Subject Area →	**Risk Assessment**
MOSS Technical Documents Reviewed →	1. *Phase 2 Marine Outfall Siting Water Quality Investigations. September 2001*
	2. *Brightwater Marine Outfall: Phase 3 Water Quality Investigations. November 2002*
Peer Reviewers →	**Michael S. Connor, Michael J. Mickelson, and Philip J.W. Roberts**
MOSS Technical Documents Reviewed →	3. *Analysis of Human Use of Puget Sound Shorelines. September 2001*
	4. *Brightwater Marine Outfall: Human Use Survey of Puget Sound Shorelines. November 2002*
Peer Reviewer →	**Michael S. Connor**

Document 1: *Phase 2 Marine Outfall Siting Water Quality Investigations. September 2001*; and Document 2: *Brightwater Marine Outfall: Phase 3 Water Quality Investigations. November 2002*.

Coordinator's Summary

The *Phase 2 Marine Outfall Siting Water Quality Investigations* report described attaining water quality standards at the edge of a hydrodynamic mixing zone, screening outfall locations, and aquatic organism and human health safety. The *Phase 3 Brightwater Marine Outfall Water Quality Investigations* report used a risk assessment approach to identify potential risks to aquatic animals and human health along shoreline regions. The three scientists were asked to review all sections for both documents.

Examples of important shared findings by two or more of the reviewers: a need for context concerning other inputs and indicators in Puget Sound; issues and concerns not usual or customary to marine outfall discharges; conservative assumptions (and methods) resulting in an overestimation of risk; assumptions not focused on issues associated with similar discharges; and the fate of the discharged effluent should be studied further.

Michael Connor: Risk assessment comments

The technical documents were reviewed separately and presented as two sets of comments. They are summarized independently below.

Summary for the *Phase 2 Marine Outfall Siting Water Quality Investigations*:

The risk assessment methodology employed during this study "was developed for the evaluation of Superfund sites," and because of its "hazardous waste cookbook" approach, focused on issues and concerns not customary to marine outfall discharges. For example, chemicals such as dichlorophenol were the focus of exposure pathway assumptions, whereas "issues associated with … lipophilic pesticides and PCBs" were ignored. Also, "because of the detection limits used, these classes of compounds [were] completely missed by the risk assessment."

Moreover, ingestion of water while swimming was emphasized as a microbial pathway of risk "rather than ingestion through contaminated shellfish." Furthermore, the "use of geometric means to evaluate risks…tends to underestimate the total loads of pathogens being discharged." The reviewer stated the "overall population risk associated with the outfall" will affect beachgoers, local fishers, and shellfishers at nearby beaches, not "scuba divers diving in the mixing zone."

It was reasonable to use data from the ACQUIRE data base to screen some chemicals from the effluents. However, the screening evaluation should "use the whole effluent toxicity testing data available for these effluents" because "these data would account for any synergistic effects of the contaminants in the effluent and the species relevant to Washington state waters."

The risk assessment approach prevented the evaluation of outfalls in the context of indicators currently used in Puget Sound (e.g., those indicators reported in the Puget Sound Water Quality Action Team [Update] 2002 report). "Particularly relevant are indicators of shellfish closures, recreational beaches, contaminated sediments, mussel PCBs and contaminants in harbor seals." Finally, the document's conclusions "are likely valid [but] the unorthodox assumptions will make it hard for the general public to believe the conclusions."

Recommendations: 1) Consider further- "what are the hypothetical exposure pathways;" 2) Obtain "effluent data where the detection limits for the lipophilic organic contaminants is in the range of EPA's human health risk assessment;" and 3) "re-think the exposure pathways of concern and develop a better data set for lipophilic contaminants."

Summary for the *Brightwater Marine Outfall: Phase 3 Water Quality Investigations*:

The "hazardous waste risk assessment issues" described in the review of the Phase 2 document are relevant here. The risk assessment should be "infused with the reality" of known risks "associated with secondary effluent discharges in the US." Further, comprehensive human exposure models relying on "rather crude" methods (e.g., sediment and fish concentrations) are indicative of the "problems of the constraints of the assessment methodology." Lastly, the risk assessment approach would likely "significantly over-estimate the [actual risks posed by the outfall] discharge based on the many over-simplifying and conservative assumptions."

The "chemical approach" used for estimating sediment concentrations "misses…entirely" the fish contaminants of concern that "tend to be associated with particles that quickly settle in the nearfield." The reviewer suggested examining "contaminant concentrations in effluent solids or sludge, compare them to baseline concentrations in the sediments, and allow them to be diluted with some background sedimentation rate."

The approach to estimate concentrations in fish was detrimental to English Sole and should have made use of NOAA's "Puget Sound Program." In addition, biomagnification was not included in the approach "which will be seen by the fishery resource agencies as a major flaw for mercury and lipophilic contaminants."

The reviewer acknowledged the AQUIRE data base "is a very useful screening tool," but was "hesitant to accept it for a full-blown risk assessment" especially since "Whole Effluent Toxicity" data was available. Finally, the "model ignore[d] fate and effects processes for the contaminants, [a] simplification [that] will vastly over-estimate risk" for many contaminants.

Recommendations: 1) The study may want to incorporate "a section on other coastal secondary discharges to put the issues in perspective;" 2) "employ a Monte Carlo methodology to reduce the cascading errors introduced by the methodology;" and 3) arsenic, dichlorophenol, and dimethylphenol "should not be highlighted in the Executive Summary."

Michael Mickelson: Chemistry comments

The technical documents were reviewed together and presented as one set of comments. They are summarized together below.

The risk assessment was calculated using "accepted procedures to show that the outfall poses little risk …despite the prevalence of nondetects in the organics data." As stated by the reviewer, "more sensitive methods are not warranted from a regulatory and risk point of view," although PCBs may "pose a problem in these exercises when you use insensitive MDLs." Finally, because it was not clear "how PCBs were handled…early in the analysis," the reviewer was "not comfortable with accepting the conclusions" without more clarification.

Recommendations: 1) "Consider the goals of monitoring. Detection of change may warrant more sensitive methods."

Philip J.W. Roberts: Modeling comments

The technical documents were reviewed separately and presented as two sets of comments. They are summarized independently below.

Summary for the *Phase 2 Marine Outfall Siting Water Quality Investigations*:

The reviewer provided comments for both the risk assessment and modeling components of the study. First, the methods used to evaluate human health exposure risks were "extremely conservative." Likewise, conservative methods and assumptions were used to "assess potential effects on aquatic organisms." For example, a human swimming continually "at the edge of the [deeply submerged] hydrodynamic mixing zone" was used to assess exposure. Similarly, it was assumed that ingested fish were "continually exposed to edge-of-mixing zone effluent concentrations."

The conservative assumptions were numerous such that the "candidate sites [could not] be meaningfully distinguished," and the "combined predicted effects [were] vastly over-estimated." Little difference was shown between the 16 sites, and despite rigorous criteria, "all are predicted to achieve the specified water quality standards."

Secondary wastewater effluent resulted in "very low" levels of fecal coliforms, and "bacterial standards [were] easily met." As a result, emphasis shifted from "bacterial exposure…to cancer risk [which, according to the reviewer,] is not a usual analysis or criteria for outfall design." A comparison to other "bathing water bacterial standards (e.g., the new World Health Organization standards)" could prove beneficial. Finally, "the water quality effects of the proposed outfall should also be put into context by comparing them with other inputs [(e.g., stormwater, river, atmospheric)] to Puget Sound."

Next, the reviewer commented on the plume and dilution modeling components of the study. Plume modeling was conducted using the "appropriate model for the specified purposes." The dilution modeling, however, was "based on very limited data." The data were "not explicitly listed," and a "discussion of variability…between the sites" was not included. The oceanographic data supporting the evaluations seemed inadequate "to differentiate between the candidate sites or to reliably predict temporal variations in water quality." Lastly, the reviewer suggested using a "measured time-series of currents, stratification, and flow" rather than "steady-state assumptions."

<u>Recommendations</u>: 1) "Reference [should] be made to actual observations of typical outfalls under similar conditions discharging similar effluents (i.e. secondary treated domestic sewage) to put these [human and aquatic organism exposure risk] predictions into context;" and 2) carefully define modeling terms (i.e., zone of initial dilution).

<u>Summary for the *Brightwater Marine Outfall: Phase 3 Water Quality Investigations*</u>:

Comments provided for the previous review are relevant here. In addition, greater attention should have been devoted to the "input data to the models and the effect on the reliability of the model predictions" rather than "estimating exposures to a long list of chemical constituents." Furthermore, "linkage" and "reference to the extensive oceanographic investigations" were not apparent. Use of the oceanographic data should be fully utilized when "assessing the fate of the discharged effluent." Finally, the reviewer felt the most important conclusion was left unstated: "the plume will be almost always submerged and exposures to the shoreline are highly improbable for all cases studied."

<u>Recommendations</u>: 1) Pay more attention to "transport on timescales of a few hours, as these can result in highest exposures at distances of a few kilometers from the outfall."

Document 1: *Phase 2 Marine Outfall Siting Water Quality Investigations*; and
Document 2: *Brightwater Marine Outfall: Phase 3 Water Quality Investigations.*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Puget Sound Peer Review

Reviewer: Michael Connor

Document	**Phase 2** Marine Outfall Siting Water Quality Investigations

General Comments

This report uses a standard US EPA methodology for risk assessment developed for the evaluation of Superfund sites to screen risks from different projected discharges. Because the methodology follows a "hazardous waste cookbook" approach, it focuses attention in a very different manner than what is the nationwide experience and concerns surrounding marine outfall discharges. The basic assumptions of exposure pathways focuses on chemicals that have never been discerned to be issues for wastewater discharges (e.g. dichlorophenol) and ignores issues associated with the very lipophilic pesticides and PCBs that have often been slightly elevated in organisms living in the nearfield area surrounding outfalls. Because of the detection limits used, these classes of compounds are completely missed by the risk assessment.

Similarly, the focus on microbial vectors emphasizes swimming ingestion rather than ingestion through contaminated shellfish which is generally perceived as a much more likely pathway of risk. This issue is particularly exacerbated by the use of geometric means to evaluate risks because the statistical technique tends to underestimate the total loads of pathogens being discharged and shellfish uptake would integrate over a reasonably long period of time. Finally, the overall population risk associated with the outfall is not to scuba divers diving in the mixing zone (not a common recreational pursuit), but to beachgoers at nearby beaches. The more relevant question would be using appropriate microbial die-off and dilution rates, what is the maximum level of exposure during a disinfection failure event at a nearby beach.

In addition, because of a lack of Washington state standards for the entire range of chemicals found in the King County effluents, data from the AQUIRE data base of aquatic toxicity were used to screen those chemicals. This approach is reasonable; however, the most straightforward way to do the screening evaluation would be to use the whole effluent toxicity testing data available for these effluents. These data would account for any synergistic effects of the range of contaminants in the effluent and the species relevant to Washington state waters—the AQUIRE data base uses data from nationwide lab tests.

Finally, by using the EPA Superfund risk assessment approach, it fails to evaluate the outfalls in the context that is the focus of all the state's education of the public about its marine waters—the indicators used by the Puget Sound Water Quality Action Team (PSWQAT) Health 2002 report. Particularly relevant are indicators of shellfish closures, recreational beaches, contaminated sediments, mussel PCBs and contaminants in harbor seals.

While the conclusions of the report—that water quality standards should be easily met by the discharge—are likely valid, the unorthodox assumptions will make it hard for the general public to believe the conclusions.

Specific Comments

Sec. 2.1, p.5 I don't characterize this assumption as hypothetically plausible. I think a lot more thought needs to go into what are the hypothetical exposure pathways. As I described above, I would focus on local fishers, shellfishers, and beachgoers.

Sec. 2.1.2, p.7 Localized sediment contamination has been the major concern for outfall discharges in San Francisco Bay and Southern California Bight.

Sec. 2.2.1, p.7 King County needs some effluent data where the detection limits for the lipophilic organic contaminants is in the range of EPA's human health risk assessment. Recent evaluations of Bay area secondary effluents measured PCBs at 1-10 ng/l.(report by Don Yee from a presentation to the 2003 CalFed conference soon to appear on the SFEI website). Boston has similar levels, and I see no reason that Seattle should vary much from that trend. These concentrations exceed the EPA human health guidelines.

Summary While the report's methods are standard risk assessment methodologies for Superfund sites, I believe the approach will impede the County's efforts to accomplish effective risk communication because it does not make the link to the extensive work done by PSWQAT. I recommend re-thinking the exposure pathways of concern and developing a better data set for lipophilic contaminants.

END OF FULL TEXT REVIEW

Puget Sound Peer Review

Reviewer: Michael Connor

Document

Phase 3 Brightwater Marine Outfall Siting Water Quality Investigations

General Comments

This report summarizes the human health and ecological risk assessment information for the outfall. It suffers from the "hazardous waste" risk assessment issues I raised in my review of the Phase 2 document (#6). I won't repeat those comments here, except to note that the issue is carried forward with arsenic. The arsenic issue in fish has been discussed by EPA for about ten years—it should not be the focus of the Executive Summary, but dismissed as a technicality. I've included two web sites I found which have some background discussion of organic versus inorganic arsenic that could be used in the report. The second level risk is from BEHP. Again, from all the work done on all the outfalls around the world, no one has raised the issue of BEHP. The risk assessment needs to be infused with the reality of what is known about risks associated with secondary effluent discharges in the US.

Similarly, dichlorophenol and dimethylphenol are artifacts of the assessment methodology and should not be highlighted in the Executive Summary.

The problems of the constraints of the assessment methodology are further evidenced by the rather crude assessment of increases in sediment and fish concentrations as compared to the very detailed human exposure models that depend on these very crude methods.

The conservative nature of the risk assessment assumptions also results in a very large overestimation of the actual risks posed by the outfall. King County would be well served to employ a Monte Carlo methodology to reduce the cascading errors introduced by the methodology.

Specific Comments

Sec. 2.3, p.10-

Shellfish consumers are exposed to very different risks from finfish consumers since most mollusks do not have an efficient Cytochrome P450 enzyme system that allows them to degrade PAHs. The biggest risk from eating mollusks is generally PAHs, while for fish it's PCBs (see reference).

Sec. 2.4, p.15	How did you account for the background build-up of contaminants from the farfield models to add to the initial dilution? Did you incorporate any degradation, volatilization, or sedimentation? What die-off rate is used for coliforms?
Sec. 2.6, p.19-	Most contaminants of concern in fish have high octanol-water partition coefficients and tend to be associated with particles that quickly settle in the nearfield. The chemical approach used here misses this issue entirely. A simple thing to do would be to look at the contaminant concentrations in effluent solids or sludge, compare them to baseline concentrations in the sediments, and allow them to be diluted with some background sedimentation rate.
Sec. 2.7, p.21-	This approach is particularly bad for English sole, which most likely receive most of their toxic contaminant load from the sediments. NOAA's Puget Sound Program that documents this issue is known nationwide. If they are involved in the ESA Biological Assessment, they will likely require a different methodology. The approach also includes no biomagnification which will be seen by the fishery resource agencies as a serious flaw for mercury and the lipophilic contaminants.
Tab 3, p.24-	I suspect the water ingestion rate is from freshwater. Drinking 50 ml of seawater would make you pretty sick.
Sec. 4.1.2.1, p.40-	I believe the AQUIRE data base is simply a compendium of reports, but not reviewed in the same level of detail as EPA does when it calculates water quality criteria. While I agree that AQUIRE is a very useful screening tool, I'm hesitant to accept it for a full-blown risk assessment, particularly since you have Whole Effluent Toxicity data.
Sec. 4.2.2., p.42-	What does the frequency distribution of all the coliform data look like? The issue is not in the average discharges, but the very upper bound releases that might affect a nearby beach.
Sec. 4.3.1, p.43-	EPA has developed a much better methodology in its 301(h) waiver program to predict DO depressions. It includes the DO depletion in the effluent, sediment BOD demand, and Phytoplankton-derived BOD (for nutrients).
Sec. 4.4, p.44-	The biggest uncertainties to me are how the model ignores fate and effects processes for the contaminants. For many contaminants, this simplification will vastly over-estimate risks.

Summary

The approach used is likely to significantly over-estimate the risks of the discharge based on the many over-simplifying and conservative assumptions it uses. However, this approach might be misunderstood if the results are used in other ways or when summarizing the study to the public.

I think the study needs a section on other coastal secondary discharges to put the issues in perspective. A rote churning of the EPA risk assessment crank is going to threaten your credibility with the resource agencies.

References

http://rm.cfsan.fda.gov/~frf/guid-as.htm/
www.ecy.wa.gov/biblio/0203075.htm/

Connor, M.S. 1984. Comparing the public health risk of fish contamination and ground water contamination by organic compounds. Environmental Science and Technology 18:628-631.

END OF CONNOR FULL TEXT REVIEW

Reviewer: Michael Mickelson

Documents Reviewed:

1. Phase 2 Marine Outfall Siting Water Quality Investigations
2. Phase 3 Brightwater Marine Outfall Water Quality Investigations

Introduction

It is clear from the reports that outfall siting is not critical: many possible locations would be OK. Evidence for this is:

3. The monitoring programs barely detect any signal at all from the existing outfalls, whether in nutrients, toxics, or pathogen indicators.
4. The effluent load is tiny compared to natural loads.

Looking toward future monitoring let me offer an impression that the monitoring program managers could review their goals, possibly leading to:

- A management decision to either choose methods which detect what is being measured, or provide an explicit explanation in the work plan of why it is responsible to merely provide an upper bound to a value with a nondetect rather than to know the actual number.
- Clarifying the monitoring responsibilities of King County to balance a restricted focus on testing for evidence of exceedance of criteria versus evaluation of patterns and processes.
- Recognition of information gaps such as how local change in nutrients is related to offshore waters versus seasonal sinking to sediments.

General Comments

The report calculates risk using accepted procedures to show that the outfall poses little risk.

The outfall risk is low despite the prevalence of nondetects in the organics data. Therefore more sensitive methods are not warranted from a regulatory and risk point of view, except that I recall that PCBs pose a problem in these exercises when you use insensitive MDLs. That is a motivation for using the better methods. I tried to follow exactly how PCBs were handled and I got the impression that they were quickly dismissed early in the analysis. I am not comfortable with accepting the conclusions until I understand this – Mike Connor can no doubt explain it to me sometime.

I will request a copy of the cited King County report describing effluent concentrations.

Recommendation: Consider the goals of monitoring. Detection of change may warrant more sensitive methods.

Specific Comments

P53. Typo in bullet 2 “00.49” : Should it be 0.0049?

Is there a typo in the header to tables 7, 8, or 9? Table 8's header reads
major/minor/ major/minor/ major/minor/
but Tables 7 and 9 deviate from that pattern, suggesting a typo.

Summary

The outfall poses little risk.

References

None

END OF MICKELSON FULL TEXT REVIEW

Review Date: March 24, 2003

Reviewer: Dr. Philip J. W. Roberts

Document: **Phase 2** Marine Outfall Siting Water Quality Investigations

General Comments

The purpose of this report is to address detailed evaluation questions (DEQs) concerning achievement of water quality standards at the edge of the mixing zone and to assess protection of aquatic organisms and human health at this location. Potential outfall sites are screened according to the relative ease of achieving specified water quality criteria. Eight candidate zones with a total of 16 sites were evaluated. Mathematical models of the initial dilution process were used to predict water quality parameters following initial dilution (i.e. at the edge of the mixing zone).

The criteria for protection of human health are based on possible exposure to effluent. The methods used are extremely conservative. For example, human exposure is based on someone swimming at the edge of the hydrodynamic mixing zone year-round. As the plume will be usually deeply submerged, this is highly unlikely to occur. Also, fish that are ingested are assumed to be derived entirely from organisms continually exposed to edge-of-mixing zone effluent concentrations. Similarly, all other assumptions are worst-case, until the combined predicted effects are vastly over-estimated and probably have little meaning.

Similar procedures and conservative assumptions are used to assess potential effects on aquatic organisms. I would recommend that reference be made to actual observations of typical outfalls under similar conditions discharging similar effluents (i.e. secondary treated domestic sewage) to put these predictions into context. Most such field observations show no measurable effects.

Because so many conservative assumptions are piled on top of each other the candidate sites cannot be meaningfully distinguished. The 16 sites show little differences, and, even with such stringent criteria, all are predicted to easily achieve the specified water quality standards. The only possible exception is a particularly stringent standard for 2,4-dichloprophenol. More refined analyses would probably show that even this could be achieved, however.

Because the water quality standards can be so easily met, this raises the question of the required level of wastewater treatment. Could the standards also be met by lesser levels of treatment? Probably this is not an issue that the wastewater agency wants to raise, but it could be stated that criteria could also be met with other treatment processes (al less cost).

The plume modeling is done primarily with the model RSB. This is an appropriate model for the specified purposes. It predicts wastewater behavior at the end of the near field (termed the hydrodynamic mixing zone in this report). The term *zone of initial dilution* are also used; these terms should be more carefully defined.

Human health protection is usually based on bacteriological considerations. In this case, the criterion is based on exposure to fecal coliforms. Because the wastewater is secondary effluent, the levels of fecal coliforms are very low and the bacterial standards are easily met. Bacterial exposure is therefore not an issue and emphasis is therefore given to cancer risk. This is not a usual analysis or criteria for outfall deign in my experience, and it is not clear if it is required here.

Comparisons with other bathing water bacterial standards would also be valuable, for example, the new World Health Organization (WHO) standards. The proposed outfalls should easily meet these standards.

The water quality effects of the proposed outfall should also be put into context by comparing them with other inputs to Puget Sound. These would particularly include stormwater runoffs, river inputs, and atmospheric inputs.

The dilution modeling is based on very limited data. Only a very few current speeds and density stratifications were apparently used. The data used are not explicitly listed, nor is there any discussion of variability of the data between the sites considered. The oceanographic data on which the evaluations were based does not seem adequate to differentiate between the candidate sites nor to reliably predict temporal variations in water quality. In particular, the density stratification data seem to be lacking, and only a small fraction of the available current data were used. Instead of steady-state assumptions using only a few combinations of effluent flow, current speed and direction, and stratification, a better approach is to use measured time-series of currents, stratification, and flow, where possible, and statistical estimates of them when not. The statistical variation of properties at the edge of the mixing zones can then be more realistically estimated.

END OF FULL TEXT REVIEW

Review Date: March 24, 2003

Reviewer: Dr. Philip J. W. Roberts

Document: Brightwater Marine Outfall Phase 3 Water Quality Investigation

General Comments

This report continues the evaluations of water quality effects of three potential outfall sites that were obtained from the previous preliminary screening procedure. It takes a risk-based approach to protection of human health and aquatic life. The health effects are primarily based on potential exposure to effluent for people recreating along the local shorelines. This recreation is confined to nearshore activities (as opposed to the previous assumption of exposure occurring primarily at the edge of the mixing zone). The Princeton Oceanographic Model (POM) was used to assess the far field wastewater transport.

Similar comments as for the previous report apply. It appears that too much attention is given to estimating exposures to a long list of chemical constituents, and insufficient attention to the quality and quantity of the input data to the models and the effect on the reliability of the model predictions. In particular, the stratifications and currents are not specified nor is there any discussion of their variability. There appears to be neither linkage nor reference to the extensive oceanographic investigations that have been undertaken. In particular, the oceanographic investigations show the flows in the region of the outfall to be very complex and often poorly captured by the oceanographic model. More direct use should be made of the oceanographic data in assessing the fate of the discharged effluent.

Again, the various mixing zones are not well defined. For example, the *acute regulatory mixing zone* (p. 42).

This lengthy report concludes that health risks from the new outfall should be low. Nowhere is the most important conclusion stated, however, that the plume will be almost always submerged and exposures to the shoreline are highly improbable for all cases studied.

Despite the shortcomings of the modeling, the main conclusions that the effects of the discharges are negligible are unlikely to change with more refined modeling.

I would recommend that more consideration be made of transport on timescales of a few hours, as these can result in highest exposures at distances of a few kilometers from the outfall.

END OF ROBERTS FULL TEXT REVIEW

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

Respondent: Doug Henderson, King County DNR

Michael Connor

Questions from the ***phase 2*** *report*: NONE

Questions from the ***phase 3*** *report*:

From the full text review- referring to Section 2.4 (page 15):

1. How did you account for the background build-up of contaminants from the farfield models to add to the initial dilution?

> *RESPONSE: Effluent reflux is accounted for in the meso-scale (POM) and basin-scale (steady-state) models. In the zone of initial hydrodynamic dilution (PLUMES model), reflux was not calculated as the increase in concentrations would be minimal.*

2. Did you incorporate any degradation, volatilization, or sedimentation?

> *RESPONSE: We did not include any degradation, volatilization, or sedimentation. Conservative chemicals were assumed to be the worst case.*

3. What die-off rate is used for coliforms?

> *RESPONSE: No die-off was assumed. While this does result in an overly conservative estimate of fecal coliform concentrations, some of the pathogens for which fecal coliforms are intended to be an indicator may have slower die-off rates than fecal coliform bacteria.*

From the full text review- referring to Section 4.2.2 (page 42):

1. What does the frequency distribution of all the coliform data look like? The issue is not in the average discharges, but the very upper bound releases that might affect a nearby beach.

> *RESPONSE: Not addressed*.

Michael Mickelson

Questions from the ***phase 3*** *report*:

General Question:

1. Please explain any management decisions to use methods that fail to detect what is being measured.

> *RESPONSE: To be answered later (submitted after questions were already answered).*

From the full text review- referring to page 53:

1. Type in bullet 2 "00.49": Should it be 0.0049?

> *RESPONSE: "00.49" is an error. The actual range should be 0.0047 to 0.0051 µg/L.*

From the full text review- referring to Tables 7, 8, and 9:

1. Table 8's header reads major/minor/ major/minor major/minor, but Tables 7 and 9 deviate from that pattern, suggesting a typo.

> *RESPONSE: The order of the columns can be switched for clarity; however, the data in the columns are correct (i.e., the X's match up with the column headings).*

Philip J.W. Roberts

*Questions from the **phase 2** report*:

1. "Because water quality standards can be so easily met, this raises the question of the required level of treatment. Could the standards also be met by lesser levels of treatment?"

> *RESPONSE: The choice of treatment technology for the new treatment plant is beyond the scope of this assessment.*

*Questions from the **phase 3** report*: NONE

Document 3: *Analysis of Human Use of Puget Sound Shorelines. September 2001*

Coordinator's Summary

The individual peer reviewer examined the entire technical document and provided various comments. First, the document achieved its goal of providing an overview of human use of marine shorelines near candidate outfall sites. The tables were useful and color-coded maps instructive, though the map would be more readable with larger fonts. The sample dates listed in Table 2 "would be easier to interpret" if information such as weather and day of week were specified. Finally, Table 8 provided an excellent summary and "should be compared to Table 1 to determine the relative use of these recreational areas to Puget Sound overall." Review of the Phase 3 report also indicated that it would be useful to compare the more detailed study in Phase 3 to the regional overview information presented here.

Document 3: *Analysis of Human Use of Puget Sound Shorelines. September 2001*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Puget Sound Peer Review

Reviewer: Michael Connor

Document	Analysis of Human Use of Puget Sound Shorelines, Phase 2
General Comments	This preliminary survey provides a brief overview of use of the areas near the marine outfall sites. The tables at the beginning and the end provide a helpful overview as do the color-coded maps showing users at the locations – a larger font for the legend would be appreciated by older readers.
Specific Comments	
Tab. 2, p.6	The sampling dates would be easier to interpret with information on the weather and day of the week – I presume the data all represent sunny weekend days.
Sec 2.1.4 p.20	The discrepancy between the observed users and reported users may be caused by the parks department over-stating their impact.
Tab. 8, p.32	This good summary table should be compared to Table 1 to determine the relative use of these recreational areas to Puget Sound overall – for instance, it appears that more people use this area for fishing relative to other boating activities in the Sound overall.
Summary	The report accomplishes its goal.

MOSS TEAM

The reviewer asked no questions.

Document 4: *Brightwater Marine Outfall: Human Use Survey of Puget Sound Shorelines. November 2002*

Coordinator's Summary

The individual peer reviewer examined the entire technical document and provided various comments. "This report is one of the most extensive surveys of its kind of the use of the northern shoreline of Puget Sound." An extensive data set was collected, and analyzed, such that these data "effectively support assumptions in other reports." This document could have benefited from a comparison between these surveys and the data presented in the Phase 2 Human Use report. The reviewer noted some other statistical concerns about how the data were presented. Finally, the three-dimensional format in Figure 8 proved difficult to understand; Figure 12 might serve as a better template.

Document 4: *Brightwater Marine Outfall: Human Use Survey of Puget Sound Shorelines. November 2002*

FULL TEXT WRITTEN COMMENTS BY THE PEER REVIEWER

Puget Sound Peer Review

Reviewer: Michael Connor

Document	Results of Human Use Survey of Puget Sound Shorelines, Phase 3
General Comments	This report is one of the most extensive surveys of its kind of the use of the northern shoreline of Puget Sound. The data are quite extensive, and the report makes strong use of statistics and graphic to summarize the data so that they effectively support assumptions in other reports. I was surprised that the report failed to compare these excellent surveys to the other activity data collected in Puget Sound that was presented in the Phase 2 report. I found the comparison to other seafood consumption data to be helpful. Why not do that comparison for the other information?
Specific Comments **Fig 8, p.15-**	I found these three dimensional figures hard to read and wondered if the 3-D format helped. A good comparison is Figure 12 on page 23, which presents the same kinds of data, but is much easier to interpret. I also wondered if it was more informative to present the absolute numbers or the percentage data. Are the numbers truly comparable or an artifact of the sampling regime?
Summary	This report is a very extensive survey of how local people use the shoreline. I was heartened to see the data incorporated into Table 3 of the Phase 3 Water Quality Investigation.

END OF FULL TEXT REVIEW

MOSS TEAM ANSWERS TO THE REVIEWER'S QUESTIONS

Respondent: David Mayfield, MOSS Team

General Questions:

1. I found the comparison to other seafood consumption data to be helpful. Why not do that comparison for the other information?

> *RESPONSE: The survey results for recreational activities (other than seafood consumption) were not compared to the preliminary results for several reasons:*
>
> *a. The available data on seafood consumption studies is robust. In addition, the methods from other studies are comparable to the MOSS survey data. Thus, a comparison of seafood consumption data is feasible and instructive.*
>
> *b. The data compiled (other than angler estimates) in the preliminary survey was very limited and was primarily based on estimates of park use. The user estimates were not conducted following a detailed sampling plan, and were primarily based on park official's observations and quantitative guesses. In addition, the available data was not categorized by time of survey or weather conditions.*
>
> *c. Also, the estimated user counts were not stratified by the type of activity; the available data was collected over brief periods of time, and primarily during the summer months. Therefore, the preliminary data were not collected in a similar fashion as the MOSS survey data. Thus, direct comparisons of the two data sets are not appropriate.*
>
> *The MOSS survey was conducted with a detailed sampling plan, and numerous variables were accounted for during the data analysis. The MOSS survey data set is considered more robust than previous estimates of recreational activity in the project area. While a comparison of the MOSS survey results with other data sets would be instructive, the quality of the previously available data may not be appropriate for comparison to the current results.*

2. I also wondered if it was more informative to present the absolute numbers or the percentage data. Are the numbers truly comparable or an artifact of the sampling regime?

> *RESPONSE: Throughout the figures and tables of this report, results are presented as absolute numbers and also as percentages. These two representations of data provide two distinct types of information. The absolute numbers provide estimates of the total volume of people attending each of the survey sites. Assuming our sampling design was performed effectively, each of*

the survey sites should have a comparable number of site visits during different times and weather conditions. Therefore, the absolute numbers should be accurate representations of the number of park users.

The percentages were also presented to provide information on the distribution of the types of activities occurring at each site. Since each of the sites was sampled in relatively the same manner, the data should provide a proper estimate of the breakdown of activity types by location.

Thus, we feel that the current presentation of both absolute numbers and percentage data provide different perspectives on the recreational uses of the survey sites (i.e., total volume of users and volume of users by activity). The sampling strategy was designed to sample all sites in a similar fashion, thus results are comparable across sites for both types of data representations. We believe that the numbers are good estimates and comparable across survey sites.

APPENDIX C

MAY 1, 2003 MEETING ATTENDEE LIST

APPENDIX C

MAY 1, 2003 MEETING ATTENDEE LIST

Name	**Organization**
Douglas R. Levin (panelist)	University of Maryland, Eastern Shore
Michael S. Connor (panelist)	San Francisco Estuary Institute
Michael J. Mickelson (panelist)	Massachusetts Water Resources Authority
Parker MacCready (panelist)	University of Washington
Aimee A. Keller (panelist)	Puget Sound region (University of Rhode Island)
Philip J.W. Roberts (panelist)	Georgia Institute of Technology
Randy Shuman	King County
Jim Simmonds	King County
Bruce Nairn	King County
Scott Mickelson	King County
Kim Stark	King County
Doug Henderson	King County
Betsy Cooper	King County
Katherine Bourbonais	King County
Martha Tuttle (facilitator)	King County
Dick Sylwester	Golder and Associates
Mike Burger	Parametrix
Matt DeBoer	Parametrix
Charlie Wisdom	Parametrix
Duane Fagergren	Puget Sound Action Team
Gigi Williams	Puget Sound Action Team
Dan Averill (coordinator)	Puget Sound Action Team

Brightwater
TREATMENT SYSTEM

King County

Final

Response to Peer Review Evaluation Report

August 2003

Prepared for King County by
Parametrix, Inc.
Kirkland, WA

For more information:
Brightwater Project
201 South Jackson Street, Suite 503
Seattle, WA 98104-3855
206-684-6799 or toll free 1-888-707-8571

Alternative formats available upon request
by calling 206-684-1280 or 711 (TTY)

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

1.0 INTRODUCTION

King County has prepared a Draft Environmental Impact Statement (Draft EIS) and Final Environmental Impact Statement (Final EIS) on the Brightwater Regional Wastewater Treatment System. The Final EIS is intended to provide decision-makers, regulatory agencies and the public with information regarding the probable significant adverse impacts of the Brightwater proposal and identify alternatives and reasonable mitigation measures.

King County Executive Ron Sims has identified a preferred alternative, which is outlined in the Final EIS. This preferred alternative is for public information only, and is not intended in any way to prejudge the County's final decision, which will be made following the issuance of the Final EIS with accompanying technical appendices, comments on the Draft EIS and responses from King County, and additional supporting information. After issuance of the Final EIS, the King County Executive will select final locations for a treatment plant, marine outfall and associated conveyances.

The County Executive authorized the preparation of a set of Technical Reports, in support of the Final EIS. These reports represent a substantial volume of additional investigation on the identified Brightwater alternatives, as appropriate, to identify probable significant adverse environmental impacts as required by the State Environmental Policy Act (SEPA). The collection of pertinent information and evaluation of impacts and mitigation measures on the Brightwater proposal is an ongoing process. The Final EIS incorporates this updated information and additional analysis of the probable significant adverse environmental impacts of the Brightwater alternatives, along with identification of reasonable mitigation measures. Additional evaluation will continue as part of meeting federal, state and local permitting requirements.

Thus, the readers of this Technical Report should take into account the preliminary nature of the data contained herein, as well as the fact that new information relating to Brightwater may become available as the permit process gets underway. It is released at this time as part of King County's commitment to share information with the public as it is being developed.

The King County Department of Natural Resources and Parks (KCDNRP) initiated the Marine Outfall Siting Study (MOSS) in 1999 to aid siting a new marine outfall for the proposed Brightwater Wastewater Treatment Facility. Twenty-eight technical documents were produced by the end of 2002 during the MOSS project Phases I, II and III (see section 9.0 for the list of documents reviewed). King County identified the need for a formal scientific peer review of the technical documents and the Puget Sound Action Team (PSAT) was contracted to coordinate the peer review process.

The six-member peer review panel members were asked to review the technical documents and comment on the MOSS scientific investigations to ensure that the information/data are sufficient to answer siting criteria questions. They were also asked to provide an objective evaluation regarding the adequacy of the scientific studies.

The reviewers completed and submitted written comments in March 2003 to the peer review coordinator from the PSAT. The review coordinator completed a technical review report, Peer Review Evaluation of the MOSS Technical Documents (PSAT, 2003), which includes a summary of the peer review process and reviewers' comments, as well as complete document reviews by each panel member. King County would like to acknowledge the time and effort the reviewers dedicated during the review process. Their objective assessment and recommedations are invaluable for planning, designing, and presenting scientific data for future studies as well as improving existing documents.

The peer review panel concluded that all 28 technical documents were acceptable. The panel judged that the MOSS scientific studies were sufficient to address the siting and design questions concerning the proposed outfall. The panel supported the overall approach utilized to address the outfall siting and design criteria, including collection of comprehensive information regarding water currents, surficial and subsurface geology, water and sediment quality, and biological resources. Extensive and appropriate scientific data were collected for the scientific investigations reported in each technical document. In Puget Sound areas where exisitng data was lacking, such as oceanographic data in the Triple Junction region and geophysical data, the panel reviewers commented that "the oceanographic studies reflected the most extensive and intensive studies undertaken in any region of Puget Sound to date" and "an exceptional data set was gathered", respectively (PSAT, 2003). For the nearshore habitat survey, a reviewer commented that this study was "an exceptional nearshore habitat study that incorporated comprehensive data collection" and was a "keystone study on which others should be modeled" (PSAT, 2003). In addition to these three studies, a comprehensive multi-year and multi-parameter water quality data set was collected as well as multi-year biological resource distribution information.

The panel found the study designs were scientifically sound and the methods were generally appropriate. The review panel identified no serious flaws in the MOSS studies. The panel did, however, recommend improvements that would strenghten the existing documents and had comments and recommendations regarding specific reports. The majority of the peer review panel's recommendations relate to the following; add more raw data to the report appendices, include additional and improved graphics, publish data in peer-reviewed literature, add more statistical analyses and redo statistics for one specific report, improve data interpretation and reporting, and continue to collect additional data in some areas.

King County would like to focus on specific comments and recommendations in this memorandum that, although not identified as a serious flaw, would strengthen an existing report or the overall MOSS project. The peer review panel's comments and recommendations listed below were taken directly from the Peer Review Evaluation of the MOSS Technical Documents report (PSAT, 2003). King County's response to specific comments and recommendations will be organized by general comments applicable to all reports and then by the six categories to which the documents pertain; geology, physical oceanography, biology, hydrodynamic modeling, chemistry, and risk assessment.

2.0 GENERAL COMMENTS

2.1. COMMENT 1

Peer Review Panel: Develop a summary report emphasizing the overall picture. Incorporate conclusions from the 28 technical documents and produce a 40 - 50 page report for the public. The report should be readable, understandable, and between a technical document and a public document in scope.

King County Response: This is a sound recommendation to integrate all the studies into one document. King County is intending to prepare a single summary document, time permitting. Meanwhile, a set of six two-page documents were produced for public distribution in June 2003 that provide a summary of the MOSS scientific investigations in a question and answer format. The format was modeled after a Massachusetts Water Quality Authority publication presenting similar information.

2.2. COMMENT 2

Peer Review Panel: Develop and submit manuscripts for publication in the peer-reviewed literature. For future work, consider producing reports targeted for peer-reviewed publication in addition to, or in lieu of, agency data reports.

King County Response: King County would like to submit articles for publication in peer-reviewed literature regarding several datasets collected, including tissue chemistry and water column metals, time permitting. For future studies, an attempt will be made to produce both agency reports and articles for the peer-reviewed literature.

2.3. COMMENT 3

Peer Review Panel: Undertake additional studies such as forage fish spawning surveys and ichthyoplankton surveys; obtain continuous stratification measurements; develop methods consistent with the University of Washington's (UW) oceanographic methods; and utilize better Method Detection Limits (MDLs) - particularly for organic contaminants.

King County Response: The suggested study to obtain continuous stratification measurements is currently underway and will continue for at least one year. An intertidal biota survey is planned in 2004 along the outfall alignment route once selected, which may include a survey of zooplankton, including ichthyoplankton. Additional forage fish spawning surveys are not planned as spawning habitat was documented in the nearshore area of the potential outfall zones and further surveys will not provide additional benefit. The intent of the forage fish spawning surveys was to determine if sand lance and surf smelt spawning habitat was present in the potential outfall zones. As spawning habitat was found in the outfall zones, there is no need for further surveys.Several additional studies have begun or are planned in the next year. These include a focused eelgrass survey along the potential outfall alignments, , additional geotechnical work, monitoring for endocrine disruptors, additional sediment chemistry sampling along the proposed alignment routes, and additional plume and transport modeling.

In regards to University of Washington methods and MDLs, method detection limits for nutrients in marine waters at the King County Environmental Laboratory are the same as or better than the University of Washington's detection limits and the quality control at the King County Environmental Laboratory is much more rigorous. All methods were conducted in accordance with the standardized Puget Sound Estuary Protocols, with some modifications necessary for specialized sampling such as low-level metals analyses.

3.0 GEOLOGY

Two primary technical documents (and one appendix) were reviewed for the geology studies. The reviewer offered specific recommendations and observations, and suggested ways to improve the existing technical documents which included:

3.1. COMMENT 4

Peer Review Panel: Both technical documents did not fully reflect the amount and quality of data collected. The reviewer felt that the appendices should contain more detailed information about QA/QC procedures as well as raw data sheets. This could be addressed relatively easily by adding this information to the existing reports

King County Response: King County plans on developing addendums for the marine geophysical investigation and conceptual geotechnical assessment reports that will contain additional data and text with detailed QA/QC information.

3.2. COMMENT 5

Peer Review Panel: The science supported the conclusions, but the conclusions could be documented more completely (i.e., add more detailed graphical support), and in general, better documentation and improved data presentation are needed.

King County Response : King County plans on developing addendums for the marine geophysical investigation and conceptual geotechnical assessment reports that will contain additional text and graphics.

4.0 PHYSICAL OCEANOGRAPHY

Three technical documents were reviewed for the physical oceanography studies. Specific recommendations to improve the existing documents offered by the reviewer included:

4.1. COMMENT 6

Peer Review Panel: Modify the Executive Summary in the final oceanography report to include the potential impacts from an outfall to Whidbey Basin (i.e., low dissolved oxygen in Whidbey Basin), and extrapolate the climate issues during the study period (i.e., dry study year and reduced freshwater river input).

King County Response: King County plans on developing an addendum to the oceanography report that will contain additional text to the executive summary on climate issues and how the physical oceanography is related to potential impacts (low dissolved oxygen).

4.2. COMMENT 7

Peer Review Panel: Improve the flow schematic diagrams (i.e., color schemes, arrows). These figures are essential for communicating information to non-oceanographers and lay audiences.

King County Response: King County plans on developing an addendum to the oceanography report that will contained improved flow schematic diagrams.

4.3. COMMENT 8

Peer Review Panel: A dry winter study period most likely affected the estuarine circulation (e.g., reduced river flows into Puget Sound); thus, an extended residence time may have been measured. This is an important observation and should be reported in the Executive Summary of the Final Report: Puget Sound Physical Oceanography

King County Response: King County plans on developing an addendum to the oceanography report that will contain additional text to the executive summary on climate issues.

5.0 BIOLOGY

Six technical documents were reviewed for the biologal studies. Literature reviews of existing biological resources as well as data from new biological studies were included in these documents. The reviewer offered specific comments and recommendations to improve the existing technical documents, as well as suggesting additional studies, that included:

5.1. COMMENT 9

Peer Review Panel: Insufficient detail for the food web section and the Dungeness crab results were deficient due to sparse data in the Biological Resources Report, Phase 2.

King County Response: The food web section was intended to provide a literature review of existing information and generalized schematics of trophic interactions. Additional Dungeness crab distribution and information was gathered for inclusion in the Final Environmental Impact Statement (FEIS).

5.2. COMMENT 10.

Peer Review Panel: Potential statistical errors were observed, and the experimental design was incompletely described in the geoduck survey report.

King County Response: King County will examine the statistical results and make appropriate changes if necessary. An errata sheet will be released should the need arise and more detail regarding experimental design and the use of statistical methods will be included in the errata sheet.

5.3. COMMENT 11.

Peer Review Panel: Rewrite the Submerged Aquatic Vegetation Patterns in the Candidate Outfall Zones report to eliminate the masking of data quality.

King County Response: This report was intended to use existing eelgrass and kelp data previously reported to determine the density patterns in the candidate outfall zones during the phase II investigations. This report will not be rewritten as the data and conclusions are included in the King County Nearshore Habitat Mapping Data Report. In addition, new eelgrass and kelp data collected in the two outfall zones is included in the FEIS Technical Appendix IV report Eelgrass Survey Results for the Brightwater Marine Outfall Alternatives.

5.4. COMMENT 12

Peer Review Panel: In general for the biological reports, include additional and better graphics, more statistics, and improved data presentation. Also, explain more completely the experimental design for each report.

King County Response: For future agency reports, peer-reviewed publications, and presentations, these recommendations will be implemented. However, due to time constraints and to the fact that these items do not change conclusions, these reports will not be rewritten.

6.0 HYDRODYNAMIC MODELING

Three technical documents were reviewed for the modeling studies. The reviewer offered specific comments and recommendations to improve the existing technical documents, as well as suggesting additional studies which include the following.

6.1. COMMENT 13

Peer Review Panel: Increase the number of density profiles and currents used in initial dilution simulations. Density profile (stratification) data were insufficient for near field modeling, and raw data for profiles and current speeds was not sufficiently reported.

King County Response: An updated initial dilution report is being prepared which will include additional density profiles and current conditions. This report will also contain the density profile data.

6.2. COMMENT 14

Peer Review Panel: Reports could be revised to more fully present study results such as the statistical distribution of rise height and dilution, reproduction of mean currents and stratification by the Princeton Ocean Model (POM), and intermediate modeling on hourly time scales.

King County Response: The initial dilution report is being revised to present statistical distributions of dilution and rise height. Additionally, King County is partnering with the University of Washington to collect stratification data on a near-hourly time scale. This is scheduled to occur over the next year, and as we receive the results we will explore the utility of documenting the comparison of this data set to the POM model..

6.3. COMMENT 15

Peer Review Panel: Continuous measurements of density stratification, improved modeling and analysis of near field behavior, and better assessment of onshore transports would improve these studies.

King County Response: Continuous water column stratification measurements will be collected for approximately one year in the vicinity of the diffuser for the preferred alignment which commenced in August 2003.

7.0 CHEMISTRY

Nine technical documents regarding water column, sediment, and tissue chemistry studies were reviewed. The reviewer offered specific comments and recommendations to improve the existing technical documents, as well as suggesting additional studies. These suggestions include:

7.1. COMMENT 16

Peer Review Panel: Relate the chemistry data to existing monitoring programs such as the Puget Sound Ambient Monitoring Program (PSAMP).

King County Response: For future reports, this recommendation will be implemented.

7.2. COMMENT 17.

Peer Review Panel: Consider new contaminants of concern (i.e., lipophilic pesticides, PCBs, dioxins, estrogen mimics).

King County Response: Monitoring for endocrine disruptors in receiving water is currently being conducted as well as participation in a national survey for endocrine disrupting compounds in wastewater effluent. These data will be presented in separate reports.

7.3. COMMENT 18.

Peer Review Panel: Strive for multi-year trends and synthesize further the water quality data presented in the 1999-2000 and 2001 Water Quality Status Reports for Marine Waters.

King County Response: The anticipated addition of one staff member to the Marine and Sediment Group in late-2003, along with additional time freed up for existing staff will allow a more-thorough analysis and synthesis of the 2002 Puget Sound water quality data. Expected additional synthesis will include: long-term trend analysis for many constituents and an assessment of the overall program, which is curerntly conducted annually.

7.4. COMMENT 19.

Peer Review Panel: Consider more sensitive detection limits for the geoduck tissue study (i.e., for PCBs).

King County Response: If further geoduck tissue analysis is required, King County will likely subcontract PCB analysis to a specialty laboratory that is able to obtain very low detection limits in tissues.

7.5. COMMENT 20.

Peer Review Panel: The Washington State sediment standards may be inappropriate (i.e., depth of sediment sampled), and the method detection limits for organics used in the sediment studies were insensitive. **Consider modifying the method detection limits.**

King County Response: It is doubtful that the Washington State Sediment Management Standards will be changed from collecting the top 10 centimeters of sediment for baseline sediment characterization studies. The 10 centimeters represents the biologically-active zone in Puget Sound and baseline sediment characterizations are required to evaluate chemical concentrations over this entire depth stratum. Once the outfall commences operation, the NPDES permit may require periodic sediment monitoring. If so, sediment samples will be collected from the top 2 centimeters as this allows a better assessment of temporal changes. The intent of the sediment characterization study was to determine if sediment chemical concentrations met applicable Washington State Sediment Management Standards chemical criteria. Method detection limits for sediment organics were below all established criteria.

7.6. COMMENT 21.

Peer Review Panel: Put sediment data into context with the Sound-wide distribution of sediments. Characterize the outfall's organic contaminant load contributions to the total sediment reservoir currently present in Puget Sound. Provide some comparison so people can better understand what is happening. This is especially important because of the concern for contamination (e.g., PCBs and dioxins) of marine animals and fish.

King County Response: The purpose of sediment sampling in the diffuser zones and nearshore areas was twofold. Sediments were sampled in the diffuser areas to evaluate any differences in chemical concentrations and benthic community structure that might have an impact on siting the outfall diffuser. Sediments were sampled in the nearshore areas to assess chemical concentrations in areas that could potentially impact outfall construction. While interesting, further analysis of the sediment data in a Puget Sound-wide context was outside the scope and budget of the study.

7.7. COMMENT 22.

Peer Review Panel: The primary productivity reports contained depth-integrated data but lacked depth-specific data. Include the depth-specific data in both reports. The report should not imply that the proposed outfall could increase the nutrients appreciably.

King County Response: The phase 3 primary productivity report will be revised to include the depth-specific data and contain additional analysis. The earlier phase 2 primary productivity report will not be revised as this was a preliminary report and the phase 3 report contains the complete dataset.

8.0 RISK ASSESSMENT

Four technical documents were reviewed for the risk assessment studies The reviewer offered specific comments and recommendations to improve the existing technical documents, as well as suggesting additional studies.

8.1. COMMENT 23.

Peer Review Panel: Although the study designs were scientifically sound, the EPA-based risk assessment failed to guide the reader toward the pertinent and important issues associated with other marine outfalls around the country (i.e., focused attention on chemicals not normally associated with marine outfalls, as well as unlikely exposure pathways [swimming ingestion]).

King County Response: King County believes that the use of standard EPA risk assessment guidelines was appropriate due to the quantity and types of comments received from the public and regulatory agencies during the outfall siting studies. King County agrees that this approach may result in lengthy discussions of parameters that present little or no risk, however, King County also believes that failure to use this approach and address these issues would result in criticism that analyses were incomplete and inadequate. Key issues, as related to marine outfalls, are also addressed in recent technical memoranda included in the FEIS. King County believes that these reports cover all risk issues that could be related to the siting, construction or operation of the future marine outfall. King County will strive in future risk assessment reports to highlight key issues.

8.2. COMMENT 24.

Peer Review Panel: Better detection limits for organics in effluent are needed; consider a Monte-Carlo approach to capture a range versus the worse case assumptions.

King County Response: The King County Environmental Laboratory uses state-of-the-art technology along with Standard Methods to achieve the best possible detection limits that are reasonably attainable with a complex matrix such as wastewater. A Monte-Carlo approach for estimating concentrations of highly censored data (i.e., mostly non-detected) was used in a recent technical memorandum included in the FEIS to evaluate effluent quality of the proposed split-stream membrane bioreactor/advanced primary treatment technology.

8.3. COMMENT 25.

Peer Review Panel: Put the wastewater discharge into context with all other loads entering Puget Sound (seek information from the TMDL process).

King County Response: This request is beyond the scope of this report. However, King County is participating in a Sea Grant proposal to develop a PCB mass balance and bioaccumulation model for the Puget Sound Central Basin.

8.4. COMMENT 26.

Peer Review Panel: Revisit the use of conservative assumptions and cancer risks, consider more fully the issue of estrogen mimics, utilize whole effluent toxicity testing, and report the density and distribution of the fecal coliform data.

King County Response: Using more realistic assumptions will only result in reduced cancer risk predictions, which will not change the overall conclusions. Therefore, due to time constraints, this report will not be rewritten.

Several estrogen mimics were analyzed for in the datasets evaluated. In addition, if effects thresholds for estrogen mimics were developed and met minimum acceptability requirements, they would have been included (although they were not explicitly highlighted in the report). Currently, King County is monitoring several endocrine disrupting chemicals (EDCs) in local surface waters. Furthermore, King County is participating in a EPA-sponsored nationwide study that is investigating this issue.

Results of whole effluent toxicity tests, as well as results of benthic community analyses, were cited in the report. These results supported the risk predictions and the overall conclusions. For future reports, these results will receive more emphasis.
A worst case scenario was used to evaluate potential pathogen risks using fecal coliform data. While using the distribution of fecal coliform concentrations would be interesting and informative, it would not change the overall conclusion of no risk. Therefore, due to time constraints, this report will not be rewritten.

9.0 REFERENCES

PSAT. 2003. Peer Review Evaluation of the Technical Documents from the Marine Outfall Siting Study. Prepared by the Puget Sound Action Team, Office of the Governor, Olympia, WA.

Documents Reviewed:

Ebbesmeyer,C., G. Cannon, B. Nairn, B. Fox, and M. Evans Hamilton. 2001. Interim Report: Puget Sound Physical Oceanography Related to the Triple Junction Region, Phase 2. Submitted to King County DNRP, Seattle, WA.

Ebbesmeyer, C.C. and G. A. Cannon. 2001. Review: Puget Sound Physical Oceanography Related to the Triple Junction Region. Submitted by Evans-Hamilton, Inc. and Puget Sound Env. Consultants, Seattle, WA.

Ebbesmeyer,C., G. Cannon, B. Nairn, B. Fox, and M. Kawase. 2002. Final Report: Puget Sound Physical Oceanography Related to the Triple Junction Region Brightwater Marine Outfall. Submitted to King County DNRP, Seattle, WA.

Golder Assoc and Parametrix. 2001. Submarine Cultural Resources Technical Memorandum. Prepared for King County DNRP, Seattle,WA.

Golder Assoc. 2002. Brightwater Marine Outfall Conveyance System Interim Conceptual Geotechnical Assessment. Submitted by Golder Associates, Redmond, WA.

Golder Assoc. 2001. Marine Geophysical Investigation: Marine Outfall Siting Study. Submitted by Golder Associates, Redmond, WA.

Golder Assoc. 2002. Brightwater Marine Outfall: A Geoduck (Panopea abrupta) Survey for the King County MOSS. Prepared by Golder Assoc., Redmond, WA.

King County. 2002. Brightwater Marine Outfall: Puget Sound Marine Modeling Report. Prepared by King County DNRP, Seattle, WA.

King County. 2001. Baseline Sediment Characterization Study, Candidate Outfall Diffuser Sites, Sampling and Analysis Plan. Prepared by King County Dept. of Nat. Resources & Parks, Seattle, WA.

King County. 2001. Existing Water Quality Conditions Study, Offshore Water Column and Intertidal Environments of the Central Puget Sound Basin, Sampling and Analysis Plan. Prepared by King County Dept. of Nat. Resources & Parks, Seattle, WA.

King County. 2001. Water Quality Status Report for Marine Waters, 1999 and 2000. Prepared by King County Dept. of Nat. Resources & Parks, Marine & Sediment Assessment Group, Seattle, WA.

King County. 2002. Brightwater Marine Outfall: Baseline Sediment Characterization Study—Sediment Chemistry and Benthic Infauna Final Report. Prepared by King County Dept. of Nat. Resources & Parks, Seattle, WA.

King County. 2002. Brightwater Marine Outfall: Geoduck Tissue Study, Final Report. Prepared by King County Dept. of Nat. Resources & Parks, Seattle, WA.

King County. 2002. Brightwater Marine Outfall: Phase 3: Initital Dilution Assessment of Potential Diffuser Zones. Prepared by King County DNRP, Seattle, WA.

King County. 2002. Geoduck Tissue Study, Brightwater Candidate Marine Outfall Zones, Sampling and Analysis Plan. Prepared by King County Dept. of Nat. Resources & Parks, Seattle, WA.

King County. 2002. Water Quality Status Report for Marine Waters, 2001. Prepared by King County Dept. of Nat. Resources & Parks, Marine & Sediment Assessment Group, Seattle, WA.

King County. 2002. Brightwater Marine Outfall Phase 3 Biological Resources Report. Prepared by King County DNRP, Seattle,WA.

King County. 2001. Biological Resources Report, Phase 2. Prepared by Striplin Env. Assoc. and Parametrix. Submitted to King County DNRP, Seattle, WA.

King County. 2001. Initital Dilution Assessment of Potential Diffuser Zones, MOSSOutfall Plume Modeling: Continuous Discharges to Puget Sound, Phase 2. Prepared by West Consultants and Parametrix for King County DNRP, Seattle, WA.

Van Voorhis, K. and J. Newton. 2002. Seasonal Patterns and Controlling Factors of Primary Production in Puget Sound's Central Basin and Possession Sound: Assessing the Role of Nutrient Limitation in Puget Sound's Central Basin and Possession Sound. Submitted to King County DNRP by Washington State Dept. of Ecology, Olympia, WA.

Nakata, K. and J. Newton. 2001. Seasonal Patterns and Controlling Factors of Primary Production in Puget Sound's Central Basin and Possession Sound Technical Memorandum. Prepared for King County Dept. of Nat. Resources & Parks, Seattle, WA.

Parametrix and Intertox. 2001. Phase 2 Marine Outfall Siting Water Quality Investigations. Submitted to King County DNRP by Parametrix and Intertox.

Parametrix and Intertox. 2002. Brightwater Marine Outfall: Phase 3 Water Quality Investigations. Submitted to King County DNRP by Parametrix and Intertox.

Parametrix. 2001. Submerged Aquatic Vegetation Patterns in Candidate Outfall Zones. Prepared for King County DNRP, Seattle, WA.

Parametrix. 2002. Brightwater Marine Outfall: Human Use Survey of Puget Sound Shorelines. Prepared for King County DNRP, Seattle, WA.

Parametrix. 2001. Analysis of Human Use of Puget Sound Shorelines. Prepared for King County DNRP, Seattle, WA.

Striplin Env. Assoc, Battelle Marine Sciences, and King County. 2001. King County Marine Habitat Report. Prepared in support of the Wastewater Treatment Division, Habitat Conservation Plan, and the Brightwater Marine Outfall Siting Study.

Woodruff, D. L, P.J. Farley, A.B. Borde, J.S. Southard, and R.M. Thom. 2001. King County Nearshore Habitat Mapping Data Report: Picnic Point to Shilshole Marina. Prepared by Battelle Marine Sciences Laboratory, Sequim, WA.